

(NASA-CR-168582) USSR SPACE LIFE SCIENCES  
DIGEST, VOLUME 2, NO. 3 Quarterly Review  
(BioTechnology, Inc.) 55 p EC A04/MF A01

N82-26952

CSCI 05A

Unclas

G3/51 24160

# **USSR Space Life Sciences Digest**

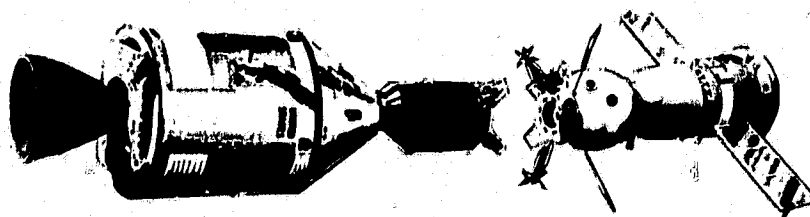
**A QUARTERLY REVIEW**

**Volume 2, Number 3**



*Prepared for the*

**Life Sciences Division  
National Aeronautics and Space Administration  
Washington, D.C. 20546**



**September 1981**

# ***USSR Space Life Sciences Digest***

**A Quarterly Review**

*Prepared for*  
**Life Sciences Division  
National Aeronautics and Space Administration  
Washington, D.C. 20546**

*Contract NASW-3223*

**September 1981**

*Prepared by*  
**Courtland S. Lewis**

**BioTechnology, Inc.  
3027 Rosemary Lane  
Falls Church, Virginia 22042**

The goal of this publication is to inform personnel of the NASA Life Sciences Division of important developments in the Soviet Space Life Sciences Program in a manner that eliminates the task of locating and reviewing the voluminous Soviet literature.

Full translations of any literature cited in the Digest may be obtained by contacting:

The Library of Congress  
Federal Research Division  
ATTN: Joseph Rowe  
Thomas Jefferson Building  
ATTIC A  
Washington, D.C. 20540

# TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION . . . . .	1
HIGHLIGHTS . . . . .	3
Launches and Recoveries . . . . .	3
New Programs . . . . .	4
Mission News . . . . .	4
Meetings . . . . .	5
GROUND-BASED RESEARCH . . . . .	6
Space Medicine and Physiology . . . . .	6
Metabolism . . . . .	6
Hypokinesia . . . . .	6
Lower Body Negative Pressure . . . . .	7
Exercise . . . . .	8
Acceleration . . . . .	8
Radiation . . . . .	9
Extreme Temperature . . . . .	9
Space Motion Sickness . . . . .	10
Circadian Rhythms . . . . .	11
Psychology Research . . . . .	13
Nutrition . . . . .	14
Crewmember Selection and Training . . . . .	14
Simulation Studies . . . . .	15
Respiratory System . . . . .	18
Cardiovascular System . . . . .	19
Space Biology . . . . .	21
Hypokinesia . . . . .	21
Radiation . . . . .	23
Pharmacology . . . . .	24
Metabolism . . . . .	24
Nutrition . . . . .	25
Respiratory System . . . . .	25
Cardiovascular System . . . . .	26
Life Sciences Technology . . . . .	27
Bioinstrumentation . . . . .	27
Toxicology . . . . .	27
Closed Life Support . . . . .	29
Exobiology . . . . .	30

## TABLE OF CONTENTS *(Continued)*

	<u>Page</u>
SPACEFLIGHT RESULTS .....	31
Space Medicine and Physiology .....	31
Mission Reviews .....	31
Cardiovascular System .....	32
Musculoskeletal System .....	32
Hematology and Immunology .....	33
Microbiology .....	33
Psychology .....	34
Radiation Effects and Protection .....	35
Clinical Aspects of Crew Health .....	35
Space Biology .....	36
Mission Reviews .....	36
Musculoskeletal System .....	36
Metabolism .....	37
Microbiology .....	37
Radiation Effects and Protection .....	38
Plant Research .....	40
Life Sciences Technology .....	40
Space Cabin Environment .....	40
Exobiology .....	41
REFERENCES .....	42

## INTRODUCTION

Soviet scientists are making significant contributions to the field of space medicine and biology through their active manned space program, frequent biosatellites, and extensive ground-based research. It is important that U.S. space life scientists be familiar with the literature generated by the Soviet program. The purpose of this document is to provide an overview of the developments and direction of the USSR Space Life Sciences Program.

Information concerning the Soviet space program makes its way into U.S. information banks and publications via a number of routes. While many agencies survey the Soviet literature and produce helpful listings and translations, no agency reviews the full scope of Soviet life science literature pertinent to the space program, and no agency is specifically charged with the task of evaluating and integrating any of this information. This Quarterly Digest is designed to bridge that gap.

The information contained in this Digest is primarily obtained from the following sources:

- Abstracts in Soviet space biology and medicine provided by the Library of Congress, Science and Technology Division.
- *Aerospace Medicine and Biology*—A continuing bibliography (NASA SP-7011).
- *Scientific and Technical Aerospace Reports*—A bibliography produced by the Scientific and Technical Information Office, NASA.
- Foreign Broadcast Information Service, Volume III, Soviet Union—NTIS. Abbreviated FBIS.
- Daily Soviet News Abstracts Publication—Translated abstracts of news items from the Soviet press. Published by Foreign Technology Division, Battelle Columbus Laboratories. Abbreviated Daily SNAP.
- *Space Biology and Aerospace Medicine*—A complete translation of the Russian language monthly journal *Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina*, published in the U.S. by Joint Publications Research Service.
- *USSR Report, Biomedical and Behavioral Science*—Translated abstracts in biochemistry, radiobiology, aerospace biology, and medicine, from a variety of Russian language sources. Published in the U.S. by Joint Publications Research Service.
- *USSR Report, Space*—Translated abstracts of formal scientific reports and news items on the Soviet space program, from a variety of foreign language sources. Published in the U.S. by Joint Publications Research Service.
- *Aviation Week & Space Technology*—Weekly periodical published by McGraw-Hill, Inc. Abbreviated *AW&ST*.
- *Astronautics and Aeronautics*—Monthly periodical published by the American Institute of Aeronautics and Astronautics, Inc.
- *Aviation, Space and Environmental Medicine*—Monthly periodical published by the Aerospace Medical Association.
- *Spaceflight*—Monthly periodical published by the British Interplanetary Society.

## HIGHLIGHTS

### Launches and Recoveries

The following table presents an overview of recent Soviet launches and recoveries.

<u>Spacecraft</u>	<u>Launch</u>	<u>Crew</u>	<u>Recovery</u>	<u>Remarks</u>
Cosmos 1279	1 Jul 1981	Unmanned		Space research
Cosmos 1280	2 Jul 1981	Unmanned		Research on Earth's natural resources
Cosmos 1281	7 Jul 1981	Unmanned		Space research
Meteor-Priroda	10 Jul 1981	Unmanned		Research on Earth's natural resources
Iskra	10 Jul 1981	Unmanned		Space research. Launched with Meteor-Priroda
Cosmos 1282	15 Jul 1981	Unmanned		Space research
Cosmos 1283	17 Jul 1981	Unmanned	July 31, 1981	Research on Earth's natural resources
Cosmos 1284	30 Jul 1981	Unmanned	12 August 1981	Research on Earth's natural resources
Raduga	31 Jul 1981	Unmanned		TV, telephone, and telegraph communications satellite
Cosmos 1285	4 Aug 1981	Unmanned		Space research
Cosmos 1286	4 Aug 1981	Unmanned		Space research
Cosmos 1287-Cosmos 1294	7 Aug 1981	Unmanned		Space research. Launched on one carrier rocket.
Intercosmos-Bulgaria 1300	7 Aug 1981	Unmanned		Research on Earth's ionosphere and magnetosphere
Cosmos 1295	12 Aug 1981	Unmanned		Space research
Cosmos 1296	14 Aug 1981	Unmanned		Space research
Cosmos 1297	18 Aug 1981	Unmanned		Space research
Cosmos 1298	21 Aug 1981	Unmanned		Space research
Cosmos 1299	25 Aug 1981	Unmanned		Space research
Cosmos 1300	25 Aug 1981	Unmanned		Space research
Cosmos 1301	27 Aug 1981	Unmanned		Research on Earth's natural resources
Cosmos 1302	28 Aug 1981	Unmanned		Space research
Vertical 9	28 Aug 1981	Unmanned		Research on shortwave solar radiation
Cosmos 1303	4 Sep 1981	Unmanned		Space research
Cosmos 1304	4 Sep 1981	Unmanned		Space research
Cosmos 1305	11 Sep 1981	Unmanned		Space research
Cosmos 1306	15 Sep 1981	Unmanned		Space research
Cosmos 1307	15 Sep 1981	Unmanned		Space research
Cosmos 1308	18 Sep 1981	Unmanned		Space research
Cosmos 1309	19 Sep 1981	Unmanned		Space research
Oreol 3	21 Sep 1981	Unmanned		Joint French-Soviet research on Earth's ionosphere, magnetosphere, and northern lights
Cosmos 1310	23 Sep 1981	Unmanned		Space research
Cosmos 1311	29 Sep 1981	Unmanned		Space research

## New Programs

- The Soviets are continuing their progress toward the goal of a permanent manned orbiting space station. Salyut 7, scheduled for launch in early 1982, will be the prototype for a modular space station core based on the successful Salyut concept. Modular "add-on" units will be similar to the Cosmos 1267 craft now docked with the orbiting Salyut 6 station. Salyut 7 has a planned design life of 4-5 years. U.S. officials have reported that, when this station is phased out in the mid-1980s, a 220,000 single-element station manned by as many as 12 cosmonauts at a time will take its place. Soviet spokesmen have not so far shed light on this report, except to say that size and manning of a multimodular station would vary with the scale of activity.
- Future expanded Salyut space station operations will involve the manufacturing of space-processed materials on an industrial scale. Materials (presumably semiconductors) processed in space will be returned to Earth and cycled into the Soviet electronics industry.
- Arianespace, the marketing organization for Europe's Ariane launch vehicle, is working to convert some of its 14 existing launch slot reservations into firm payload bookings. Overall Ariane program responsibility will be shifted from the European Space Agency to Arianespace, a private company, in 1983.

## Mission News

- Soyuz 6, designed for an 18-month life span, began its fifth year in orbit on September 29. Since June 19 it has been docked with the artificial Earth satellite Cosmos 1267 for tests of onboard systems and equipment. These tests include life support, electrical, thermal, and other interface tests related to the attachment of modules to a central space station core. Although additional automated missions are anticipated, no further manned mission to Salyut 6 will be flown.
- Using the *Sp/av* furnace and the *Kristall* unit in materials-science experiments aboard the Salyut 6 station, a total of about 200 specimens of compounds with new physical properties were obtained. These substances are said to be highly significant for such fields as infrared technology, microelectronics, radio engineering, quantum electronics, optical electronics, electrical engineering, and computer technology.
- Scientific instruments carried by Soviet research satellites have detected a runoff of particles of the Earth's radiation belts over areas presenting negative magnetic anomalies.



## Meetings

- On July 13 a press conference on the results of the five long-term Salyut-6 missions was held in Moscow. Principal speakers included cosmonauts, space scientists, and directors of the Soviet space program. Anatoliy Aleksandrov, president of the USSR Academy of Sciences, emphasized in his remarks the value of photographic and visual observations of the Earth's surface. Cosmonaut Aleksey Yeliseyev discussed the transport vehicles and support equipment used in the Salyut 6 missions, noting that more than 1,600 experiments were performed during the nearly five years of intermittent manned operation. Cosmonaut Aleksandr Ivanchenkov answered the questions of Soviet and foreign journalists regarding the prospects for longer-term space stations and the direction of Soviet space station development. Academician O.G. Gazenko spoke on the outlook for more prolonged individual flights, while R.Z. Sagdeyev, director of the Academy of Sciences' Institute of Space Research, commented on the results of space-technology experiments conducted aboard Salyut 6. Aleksey Leonov, deputy head of the Cosmonaut Training Center imeni Gagarin, discussed features of the selection and training of space crews and the support of flights.
- The Seventh International Congress on Hyperbaric Medicine was held in Moscow, under the chairmanship of academician B.V. Petrovskiy. Focuses of the conference were on the use of hyperbaric oxygenation in the treatment of disease and on the physiological effects of a hyperbaric environment and oxygen intoxication.

---

(Material in the "Highlights" is drawn from SWB, July-September 1981; FBIS, July-September 1981; Daily SNAP, July-September 1981; and AW&ST, July-September 1981.)

## GROUND-BASED RESEARCH

### Space Medicine and Physiology

#### Metabolism

*Key words: aging, metabolism, body temperature, hypothalamus, cardiovascular system*

Control of the aging process in humans is the subject of a review monograph by Chebotarev and Frol'kis (1981). Although the lifespan of insects can be increased tens of times simply by a slight ( $5^{\circ}$ - $10^{\circ}$ C) reduction in temperature, in more highly organized animals the process of aging is more difficult to control. However, a number of approaches have shown promise. Artificial control of the hypothalamus is being investigated as one means of retarding aging through reduction in body temperature. Certain drugs which normalize aspects of mediator metabolism have been shown to extend life in the elderly. Long-term low-calorie diets produce less marked age changes of the cardiovascular system and the metabolism than are seen among those who consume high-calorie foods. In addition, the longer lifespan of women than men is partly explained by a difference in hormone metabolism—hormones affect cardiovascular pathology.

*Key words: ionized air, confinement, 11-hydroxycorticosteroids, triglycerides, enzyme activity*

Ionized air, with a preponderance of positive aeroions, is one of the factors to which man is exposed in a spacecraft cabin. To further explore the physiological effects of this environmental factor on man, Anisimov and associates (1981) studied various biochemical parameters of the blood and urine of healthy men exposed to ionized air while in a confined space. Subjects were confined to small enclosures for 16 days, with relatively stable microclimate and with exercise for 1 hour daily. Enzyme activity and the content of 11-hydroxycorticosteroids (11-HOCS) and triglycerides in the blood, as well as the content of 17-ketosteroids in the urine, were measured. Enzyme activity did not change during the period of confinement. The other parameters all increased by days 7-9; presumably these increases were due to activation of the hypophyseal-adrenal system in response to enclosure. A subsequent rapid return of the parameters to normal was attributed to the cumulative effect of air ionization.

#### Hypokinesia

*Key words: bedrest, spaceflight, hypokinesia, neurophysiology, pathology*

A review of the book *Clinical Neuropsychology and the Pathology of Hypokinesia* was received (Lekar', 1981). The book, deals with extended bedrest, lengthy spaceflights, and various external factors as they are related to hypokinesia. The authors present a classification system including normal and pathological conditions, with extreme tension of regulatory mechanisms being cited as a leading pathogen. Current understanding of deep brain structures and spinal regulators is summarized, along with a discussion of motivational factors and neurological/psychological disturbances in both clinical and practical situations. The final chapters of the book deal with clinical aspects of bedrest and preventive measures.

*Key words: bedrest, bone strength, bone mineral composition*

Stupakov and coworkers (1981) compared the strength and mineral composition of T<sub>10</sub>-L<sub>3</sub> vertebrae obtained from young adults who had died suddenly after 20-45 days of bedrest with those of subjects who had met with accidental death. Comparison of mechanical data showed that prolonged bed confinement markedly reduced the strength of vertebrae. This loss of strength was ascribed to the loss of Ca, leading to an altered chemical composition of bone. Other chemical changes included marked elevation of Na and, particularly, K concentrations.

*Key words: stress pathogenesis, immobilization, hypokinesia, RNA, proteins*

In an effort to demonstrate the pathogenesis of the stress reaction, Khaydarli (1980) ran a series of tests using a variety of stress stimuli: hypoxic hypoxia, hyperthermia, immobilization, hypokinesia, and swimming. Measurements were made of the effect of each type of stress on RNA, basic, and general protein content in the motor neurons of the ventrolateral core of the frontal portions of the spinal cord. In most cases an increase was found in the content of these substances in the spinal cord, and to a lesser extent in cell protein levels. Additionally, it was found that the rate of decomposition of RNA and proteins in the supraoptical and paraventricular nuclei of the hypothalamus and cerebellum exceeded their rate of synthesis. Immobilization and hypokinesia occupied intermediate positions between the other stress stimuli in terms of the effect on RNA and protein content.

*Key words: hypodynamia, hypogravity, hypergravity, motor reaction, muscular endurance*

Alelyukhin and Khachatur'yants (1980) tested the physiological effects on operators of 10 days of hypodynamia. Operators were divided into three groups: control, a group with simulation of hypogravity, and a group with simulation of hypergravity. Measurements were made of simple motor reaction, muscular endurance, tremor, critical fusion frequency, and "tapping test" (s/c). Substantial differences were demonstrated in the dynamics of all three groups of subjects according to the first three methods. No changes were found with regard to critical fusion frequency or the "tapping test."

### **Lower Body Negative Pressure**

*Key words: hypertensive neurocirculatory dystonia, cardiovascular function, response to LBNP, flight qualification*

Hypertensive neurocirculatory dystonia (HND) has increased in frequency over the past decade. Although this cardiovascular disorder is one of the most common conditions leading to disqualification of young flight personnel, not enough is known about its etiology and pathogenesis. Suvorov et al. (1981) studied cardiovascular function and tolerance of lower body negative pressure (LBNP) among a group of pilots with HND. They found that most dystonic subjects (87 percent) showed high tolerance to LBNP exposure, although they had distinctly peculiar cardiovascular compensatory reactions during the tests. Their cardiovascular function was compensated by means of an

Increased arterial tone, compared to healthy control subjects. However, some 13 percent of the subjects with HND displayed failures of cardiovascular compensatory reserves, losing the ability to maintain high arterial tone in response to LBNP. Such provocative tests are useful in identifying pilots with HND who have adequate compensatory capability and can thus be flight qualified.

### Exercise

*Key words: venous pumps, skeletal muscle micropumping, exercise, readaptation*

A book by Arinichin (1980) deals with the venous pumps, or "peripheral hearts," that may contribute to circulation of the blood. In a section entitled "Movement and Space," he discusses the impact of this factor and that of the suction-pumping micropump activity of skeletal muscles on the circulation of cosmonauts in weightlessness. A particular focus is on the effect that preflight physical training and sports activity, as well as inflight physical exercise, have in maximizing the contribution of these secondary pumps. The resulting improved circulation and conditioning provide higher work efficiency inflight and easier readaption to gravity postflight.

*Key words: physical training, ultraviolet (UV) light, immunity*

Investigation of various means of enhancing non-specific resistance among sailors at sea (Novikov & Arzumanov, 1981) showed that physical training (30 min/day) combined with tempering (rubdowns with wet sheets, along with UV irradiation) was the most effective in enhancing natural immunity. Other experimental groups were exposed to: UV light only (0.25-2.5 biodose per day, increasing over a 10-day period); oxygen inhalation (30 min/day for 10 days); and electrosleep (60 min/day for 10 days). In addition, all groups were given 100 mg/day of vitamin C.

### Acceleration

*Key words: nystagmus, vestibular analyzer, oscillatory rotation, sine rotation*

A method that has lately come into greater clinical use for studying the vestibular analyzer is oscillatory (or sine) rotation. Following uniform acceleration and deceleration in one direction, the direction of rotation is reversed. This technique for stimulating the labyrinth avoids the problematical response reactions seen during negative acceleration when rotation is in one direction only. Using oscillatory rotation, Pal'chun et al. (1981) found the basic characteristics of nystagmus in healthy persons to be: (1) rhythm is correct and retains a specific frequency throughout the study; (2) frequency varies among individuals, ranging from 2 to 4 beats per second; (3) amplitude is calculated by calibrating the movement of the eyeballs through  $20^{\circ}$ ; (4) slow phase nystagmus is directly proportional to the frequency of nystagmus, and ranges from  $16.8^{\circ}$  to  $67.4^{\circ}$  per second.

**Key words:** *nystagmus, vestibular analyzer, Coriolis acceleration*

Since nystagmus is a reaction to functional load on the vestibular analyzer, Sidel'nikov (1981) proposed that stimulation of the cupula and labyrinthine apparatus should affect the degree of nystagmus. If so, it would provide a basis for a reproducible test to assess the sensitivity and stability of the vestibular analyzer in cumulative Coriolis accelerations. When electronystagmograms were taken before, during, and after rotation testing, with constant cumulative Coriolis acceleration as a final test, results showed that subjects fell into one of two groups. Group 1 subjects, who showed manifestations of vestibular-autonomic reactions, had increased slow-phase nystagmus. Group 2, those without vestibular-autonomic reactions, displayed significant decreases in slow-phase nystagmus. These response groups corresponded to vestibular-stable and vestibular-unstable subjects, respectively.

## **Radiation**

**Key words:** *radiation dosage, hematopoiesis, mathematical models*

Attempts to derive dosimetric criteria for assessing radiation injuries in man resulting from partial or whole-body radiation, whether accidental, environmental, or therapeutic, have not been satisfactory. In an older article received recently, Glazkov and coworkers (1978) reported their use of a mathematical model, based on a function expressing the activity of bone marrow hematopoiesis and using published findings on bone marrow neutrophil changes resulting from accidental irradiation in man, to calculate the status of bone marrow hematopoiesis as a function of radioactive dosage. Good agreement was reported between computed results and available clinical data for both man and dogs.

## **Extreme Temperature**

**Key words:** *high/low temperatures, protection, thermal state*

A review of a recent book (Azhayev, 1981) dealing with the effects of high and low temperatures was received. The book summarizes the existing literature and the author's research on the effects of high and low temperatures on man, as well as methods of personal protection against adverse microclimate conditions. There are chapters dealing with current methods for studying man's thermal state and the effects of high temperature—especially in terms of metabolism, hemodynamics, and heat transfer. One chapter discusses individual protection of flight crews against high ambient temperatures. Another section presents a classification of the thermal states of man on the basis of changes in parameters of functional systems involved in heat regulation. The reviewer remarks that this is the first published work combining experimental data on the effects of both high and low temperatures.

*Key words: adaptation, metabolism, cold environment, polar stress syndrome*

In a monograph intended for specialists concerned with problems of man's adaptation to long-term extreme factors, Kaznacheyev (1980) reviewed existing literature and recent investigations dealing with human adaptation to high latitudes. The review focuses principally on aspects of the "polar stress syndrome" found in Arctic populations, and, as such, much of the discussion is concerned with public health questions. However, there is a lengthy treatment of adaptation mechanisms and pathological processes related to cold environments. Results of field studies are systematized according to biological level of organization. At the molecular and cellular level, adaptive changes were found to be characterized by intensification of free-radical oxidation of lipids, with a corresponding decline in antioxidative activity. At the organismic level, the most important adaptive change was a change in regulatory mechanisms, primarily in neuroendocrine regulation. Changes in the metabolism of proteins, fats, carbohydrates, vitamins, macroelements, and trace elements have an impact on the optimum dietary intake under such conditions.

*Key words: high temperature, resistance to stress, physical training*

Sulimo-Samuylo and colleagues (1981) reported the responses of physically trained and untrained subjects to high-temperature stress tests at 40° C. The physically trained subjects were able to continue with a 250-watt stress test 1.5 times longer than the untrained individuals. They benefited from increased oxygen supply and from a more rapid recovery of cardiovascular and respiratory functions. In untrained subjects, adaptation to stress conditions occurred primarily through increased heart activity. Capacity for mental work decreased during the tests in the untrained subjects, and the differential thresholds of the auditory analyzer and the sensorimotor response were higher. Indices of mental activity were more stable in trained subjects. The authors concluded that resistance to high temperature during initial adaptation may be increased 20%-30% by physical training.

### **Space Motion Sickness**

*Key words: motion sickness, quantitative evaluation, human tolerance, vestibular tests*

Motion sickness is characterized by symptoms involving many functional systems of the body. The severity of these symptoms can fluctuate over a wide range. For these reasons it has been difficult to objectively evaluate motion sickness. Galle (1981) developed a method for making a quantitative evaluation of clinical manifestations of motion sickness. The procedure involves scoring 8 major symptoms of motion sickness—vertigo, nausea, vomiting, sweating, paleness, headache, sleepiness, and flaccidity—in terms of the degree of manifestation. This differs from a system used by American researchers in that such symptoms as vertigo, headache, and listlessness are given equal status with the more prominent clinical symptoms. The scores on vestibular tests (tolerance to cross-coupled acceleration) provided the basis for the author's recommendation of quantitative criteria of human tolerance to vestibular exposures.

*Key words: stressors, vestibular system, motion sickness, trigeminal nerve, hypothalamus*

Arlashchenko (1981) discusses vestibular stimuli, such as those encountered in spaceflight, as being related in their effects to many other stressors such as radiation, intoxication, and trauma. He asserts that the autonomic reaction, manifested as symptoms of motion sickness, found in each of these cases is an "adaptive-trophic" one, directed at maintenance of stability of the endogenous environment and involving the main center of autonomic function regulation, the hypothalamus. Evidence for the innervation of the vestibular system by the trigeminal nerve is presented, based largely on observations of reactions in animals to surgery on the inner ear and injury or destruction of the trigeminal nerve. A number of possible mechanisms for this type of pathway in weightlessness are proposed, using removal of weight pressure and redistribution of fluids as a trigger. These and other arguments support the concept of an independent reflex pathway of vestibulovegetative reactions, with the sensory trigeminal nerve as the starting element and the reticular formation and hypothalamus as central elements.

*Key words: vestibular function, visual analyzer, auditory analyzer, circadian rhythms, hypoglycemia*

A book by the Bulgarian otoneurologist A.N. Kekhayov (1978) reports his clinical and experimental investigations into the function of the vestibular, visual, and auditory analyzers. His approach is relativistic, attempting to correlate vestibular functions with those of the visual and auditory analyzers on the basis of neurophysiological studies, clinical observations, and biochemical investigations. The book covers such topics as vertigo and the effects of the vestibular apparatus on color vision, sound intensity, and temporal perceptions. The author demonstrates that noise, acceleration, high speed, and vibration may affect circadian rhythms, particularly in subjects with disturbances of time and space perception, and that vestibular stimulation may result in pronounced hypoglycemia.

## **Circadian Rhythms**

*Key words: biorhythms, adaptation, work fitness*

A monograph by Moiseyeva and Sysuyev (1981) examines the structure and regulation of biorhythms and discusses their use as a diagnostic tool. The authors demonstrate that there is circadian and ultradian rhythm in many physiological functions seen in adaptive and adjustment processes. The origin and regulation of these biological rhythms are still unresolved. In examining heliogeophysical and cosmic factors, they found that changes in Earth's magnetic field affect physiological rhythms, while solar (and related weather) activity changes modulate biological rhythms primarily. Each organism forms a complex biorhythmic system based, according to the authors, on the individual's intrinsic time scale. In these systems, rhythms with a greater period modulate rhythms with a lesser period. Adaptation to regularly occurring or unpredictable (stressor) changes in the environment is a complex function of the degree of organization of components of

this system and their range of variability. The authors propose some criteria of adaptability based on biorhythms which are recommended for use in forecasting fitness for work under extreme conditions and predicting the outcome of disease states. The prognostic signs are: (1) good organization of the circadian curve; (2) relatively high mean values and scatter of these values over a 24-hr period; (3) relatively constant position of the aerophase when tested repeatedly over several days.

*Key words: desynchronosis, biorhythms, genorhythms, spacecrew selection*

An article by Tyurin (1980) discusses the "desynchronosis" syndrome encountered in space and methods of counteracting or avoiding this mismatching of somatic rhythms. For example, on the assumption that biorhythms are a conditioned reflex the crew of the 140-day Soyuz 29/Salyut 6 mission was put on a 24-hour day synchronized to Moscow time, with a 5-day work week. Individual energy output/information processing patterns are discussed. The author suggests that every individual has a natural rhythm, independent of the terrestrial environment. Such "genorhythms" can be used to select space crews according to the requirements of each specific flight. Another proposal is that candidates could be selected based on the constancy of their biorhythms. Individuals with high biorhythmic constancy adapt more successfully to altered regimens and endure desynchronosis more easily.

*Key words: long-term continuous activity, visual-motor activity, mental efficiency*

Few experiments involving continuous activity of more than 24 hours have been conducted. A study by Ivanov (1980) investigated the efficiency of human operators during 3 days of continuous activity in a sealed room, without contact with the researcher, and in total isolation from external information, auditory stimuli, and natural illumination. Visual-motor and mental tests revealed that human operator efficiency undergoes cyclical circadian changes over a 24-hour period. The degree of change is different for different tests: motor activity changes the most, followed by visual search and recognition ability. Intellectual functions change the least. The amplitude of change tends to increase in each successive cycle. It was found that respiration rate does not exhibit circadian rhythm. Additionally, athletes showed increased cardiac rate, and non-athletes a decreased rate.

*Key words: sleep stages, duration of sleep, sleep-wake cycles, work fitness*

A review article (Kandror & Rotenberg, 1980) examines the relationships between sleep patterns (duration, scheduling, and sleep stages) and fitness for work. According to the "law of Yerkes-Dodson," fitness for work diminishes not only when wakefulness and motivation are low, but also when there is excessively high motivation and (unproductive) activity, as in a state of extreme emotional excitement. Every type of productive activity apparently has an optimum activity level, with levels above and below the optimum contributing to lowered productivity. The slow-wave (delta) and rapid eye movement (REM, or paradoxical) sleep stages are also discussed in terms of their functional differences. Delta sleep appears to be important for organization of



mnesic functions, while REM sleep seems to elicit emotional adaptation to new and significant information, thus reducing emotional stress. The relative need for REM sleep is a function of personality type, and thus helps to determine total individual sleep requirement and reaction to sleep deprivation. The need for delta sleep is satisfied first, at the expense of REM sleep. If sleep time is gradually reduced, work fitness is maintained down to a certain critical level (5.5 hr per day for most individuals; but loss of REM sleep progressively worsens performance of tasks requiring creative thinking. A loss of REM sleep is also associated with poor adjustment to altered sleep-wake cycles. The relationship between circadian rhythm and altered sleep patterns is highly significant in determining work fitness,

*Key words: biorhythms, industrial work, selection, accident rate, productivity*

The Soviets are beginning to apply biorhythmology on an experimental basis in industrial and other workplaces where there are potentially dangerous or extreme working conditions. Two such studies reported by Tkachenko (1981), in which individuals were selected for hazardous or demanding assignments on the basis of their biorhythmic fitness, revealed that the accident rate is higher during critical or dangerous periods of the cycles. When both plants began routinely using the biorhythm system to place and transfer workers, industrial traumatism fell drastically, quality and productivity of work improved, and fewer mistakes were made.

## **Psychology Research**

*Key words: psychology, behavioral analysis*

Lomov (1981) reviews recent concepts and advances in psychology, in particular those relating to advancements in fields such as space exploration. The case is made for analysis of behavior at several different levels: the macrolevel (total human), mesolevel (mental function in relation to life), and microlevel (neurophysiologic mechanisms of mental activity).

*Key words: interpersonal communication, small group isolation, performance*

Novikov (1980) discusses various sociopsychological and ecopsychological aspects of interpersonal communication in autonomous situations such as spaceflight. Considerable attention is devoted to social isolation and conflicts that may arise within a limited space in a hostile environment (e.g., a spacecraft), and to consequent negative physiological and mental sequelae that impact the ability to perform required tasks.

*Key words: systems analysis, fatigue, operator error, time availability*

An article by Pikovskiy and Khachatur'yants (1980) presents a functional systems analysis of changes in automated activity in the discrete-continuous and continuous tracking modes when operators are tired. Specific mistakes, keyed to type of tracking, are described. It is proposed that

functional shortage of time is the main condition lowering operator efficiency. A solution is to enhance the operator's functional resistance by means of purposeful psychological design of activity relative to adverse environmental factors.

*Key words: group operator interactions, retention of skills*

Lebedeva and Pikovskiy (1980) describe methods used to study the process of formation and execution of sensorimotor skills in the interaction of two operators in performing tracking tasks. These methods lend themselves to the study of problems of operator compatibility, alternating leadership, and stability of skills under adverse working conditions. Differences between this methodology and conventional methods of studying group operator activity are outlined.

## **Nutrition**

*Key words: space greenhouse, higher plant wastes, nutrient value*

In view of the limited space and energy that could be dedicated to the support of an onboard "space greenhouse," it is important to maximize the total food output of the system. One approach is to extract the usable nutrients from normally inedible portions of higher plants grown for food. Fofanov and coworkers (1981) tested the feasibility of this approach, using juice obtained from beet and carrot tops and from cabbage and pea waste. The juices were analyzed for content of protein, carbohydrates, ash, some vitamins, amino acids, and nitrogen. On the basis of analysis results, it was determined that the biological value of juice protein is too low to satisfy total human protein requirements. However, it can be used as a source of supplemental protein, minerals, and vitamins. To test for toxicity, the juices were fed to rats; no signs of poisoning were detected. Human subjects then consumed the products for 15-45 days along with a normal diet designed for spacecraft crews. *Chlorella* biomass was added during the last 15 days. Work capacity remained unaffected and no ill effects were observed. Metabolic and physiological tests all indicated that the diet was adequate.

## **Crewmember Selection and Training**

*Key words: stress, simulator training, flight preparedness, self-managed training*

Results of a study of the relationship between nervous emotional stress and training effectiveness were received. The authors (Pleshan' & Kozlovskiy, 1981) hypothesized that a pilot's level of emotional stress during flight simulator training indicates his level of flight preparedness and his degree of mastery of flight requirements. The "Physiolog" apparatus was used to measure emotional stress by monitoring changes in physiological parameters: pulse and respiratory rate and minute respiratory volume. Scoring of pilots in simulator training was carried out according to variations in these measures. Comparison of these scores with evaluations of actual flight performance showed a high degree of correlation. The technique also allows specific areas of weakness to be identified and corrected. It makes student self-management of training possible, particularly in the case of lesser-skilled pilots.

*Key words: cosmonaut selection, training program development, psychological factors*

An article entitled *On the History of Training the First Cosmonauts*, by Ye.A. Karpov (1981), is included in a book celebrating the 20th anniversary of Gagarin's flight. It describes in some detail the difficulties involved in developing selection procedures and a comprehensive training program, in the absence of any prior experience in this area. This highly anecdotal account by the first head of Cosmonaut Training Center imeni Yu.A. Gagarin conveys a strong sense of the inventive, flexible, cooperative approach that had to be taken in every aspect of the program. Highlights are the descriptions of the reaction of cosmonaut trainees to special or periodic training "measures" such as parachute jumps (at night and over water), heat loading, and centrifugation to provide vestibular conditioning. Controlling the high levels of excitement and psychological tension was a continual factor. The problems encountered in developing a simulator and a program for training on the simulator (initially consisting of a two-page checklist) are also described.

*Key words: survival, extreme environments, space crew training*

A book by V.G. Volovich (1980), a scholar in problems of survival, systematizes information needed for the self-contained preservation of life and health in critical situations under a wide range of environmental conditions. Finding potable water, collecting food, building shelter, and treating trauma and disease are the subjects of attention. Information is based on the author's own research in extreme habitats.

## **Simulation Studies**

*Key words: mathematical models, physiological functions, regulation*

A monograph by Amosov (1977) reports the use of mathematical modeling with digital computers to investigate regulation of the major physiological functions of the human body: circulation, respiration, fluid-electrolyte metabolism, and heat regulation. General conclusions about self-regulating properties are derived. The digital models were integrated into a complex model of interrelated physiological systems of the body, which was then used to study the regulation of functions during simulation of physical and heat loads, as well as some pathological changes in cardiac function. The focus is on the quantitative characteristics of the model and comparisons of these data with data obtained from experimental physiological studies.

*Key words: mathematical modeling, circulatory regulation, body position, LBNP*

Grigoryan and Palets (1980) discuss mathematical modeling of circulatory regulation with change in the spatial position of the body and application of lower body negative pressure (LBNP). A comparison of these two factors reveals similarities and differences in their effects on regulation, as well as their possible value as diagnostic tools.

*Key words: cybernetics, blood volume, hemodynamics, orthostatic tests*

As part of a collection of articles dealing with medical and physiological cybernetics, Lissova (1980) contributed a comparative analysis of the effect of changes in total blood volume on hemodynamics during orthostatic tests. The article discusses similarities and differences found between orthostatic and antiorthostatic conditions, in terms of the effects on both hemodynamic parameters and regulatory reactions.

*Key words: mathematical model, cardiovascular system, postural test, exercise test*

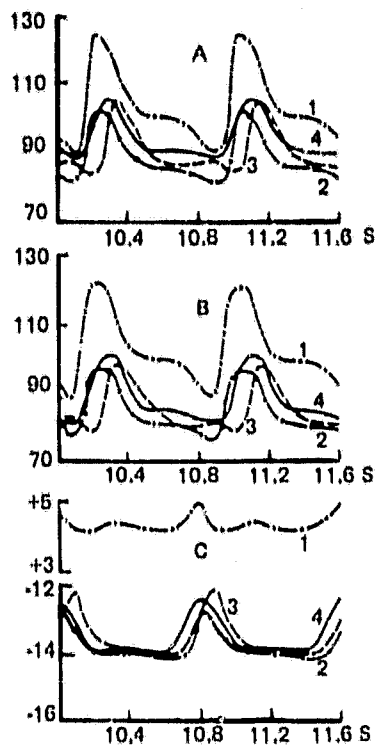
To investigate the effects of gravity factors on the function of the cardiovascular system, Arsent'yeva (1981) developed a mathematical model which he used to study dynamic reactions of the system to postural and exercise tests. The model consists of 34 compartments representing arterial and venous subsystems of the systemic and pulmonary circulation, arterio-venous capillaries, and the right and left ventricles and atria of the heart. It describes pulsating blood flows and pressure/volume changes during a cardiac cycle in each compartment. Some results are shown in the two graphs on the following page. The first figure shows a simulation of the state of the cardiovascular system beginning 10 sec after a sudden shift from supine to standing position. The second figure shows the simulated reaction of the circulatory system to exercise in the supine position. Results conform well with experimental data.

*Key words: fluid shifts, simulation, Chibis, vestibular function tests*

Head-down tilt is ordinarily used to simulate the cephalad fluid shifts seen in weightlessness. However, the method is not useful for studying vestibular disturbances because such parameters as the resistance of the vestibular analyzer to Coriolis accelerations cannot be evaluated. To devise an alternative means of modeling the weightless fluid redistribution, Lapayev and associates (1981) modified the Chibis protective vacuum suit to provide positive (instead of the usual negative) pressure to the lower body, allowing vestibular function tests. The modifications consisted of attaching a micropump capable of operating in both positive and negative (air in or air out) pressure modes, rendering the garment airtight at the waist, and using a single manometer to monitor positive and negative pressures. The authors report that they have used the altered Chibis suit successfully in experimental tests.

*Key words: mathematical model, perspiration, temperature regulation, hypothalamus*

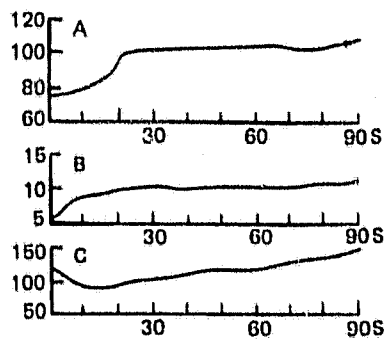
The regulatory perspiration response in man at rest, at elevated ambient air temperature, was studied on a mathematical model of the temperature regulation system in which perspiration as a regulating activity was determined by variation of brain temperature (Yermakova & Ivanov, 1978). The vasodilating response of the skin began during the few minutes of exposure at 40° C. Within 30 min, the volume flow rate of blood in the skin had increased sixfold. Perspiration began at the end of the 30-min latent period. The mathematical model showed a perspiration rate of 2.60 g/min with uniform blood flow and perspiration throughout the entire skin area. Based on the model, temperature homeostasis of the human body could be effectively regulated by the temperature of the hypothalamus.



Arterial and venous pressure reaction to orthostatic position.

- a) pressure in ascending aorta and aortic arch (mmHg)
- b) pressure in common carotid arteries (mmHg)
- c) pressure in jugular veins (mmHg)
- 1) supine state without consideration of controlling influences
- 2) change from supine to standing position
- 3) erect state with baroreceptor control of heart rate
- 4) consideration of additional control by resistance of arterial vessels of the legs.

X-axis, time after 10th sec of positional change.



Reaction of circulatory system to 600 kg-m/min exercise in supine position. X-axis, time (sec).

- a) heart rate per min
- b) cardiac output (l/min)
- c) systolic pressure in aortic arch and ascending aorta (mmHg).

*Key words: mathematical modeling, immune system, immunological processes*

Spaceflight alters the immunological status of animals and man. Observed changes such as diminished immunoreactivity increase the probability of disease in the altered microbial environment of a spacecraft. The mathematical modeling of such immunological phenomena has become an increasingly important tool of space medicine. Krut'ko (1981) reviewed the current status of the application of models to immunological processes, and summarized the capabilities of these techniques. He divides existing models into two classes: models of the immune system as a whole, and models of individual immunological phenomena. Models of the first type are more fundamental and theoretical, but because they are comparatively comprehensive they do not lend themselves to accurate simulation of immunological mechanisms and reactions. Useful quantitative data are difficult to derive with them. However, they are valuable for testing conflicting hypotheses for feasibility; and they provide the methodological foundation for the development of models of the second type. The latter models are used to analyze the details of immune system function and antigen activity both in vivo and in vitro. The author examines a large number of specific models of this type.

*Key words: mathematical model, semicircular canals, rotation, location*

Sarkisov (1981) constructed a mathematical model of the semicircular canals of the labyrinth, and used it to study the effect of location in a moving device on function of the canals in man. The objective was to determine the orientation that produces minimal and maximal vestibular effects. System movements studied were: accelerated rotation about a stationary axis, regular procession, and man's movements in an evenly revolving system.

## **Respiratory System**

*Key words: respiration, gas mixtures, gas density*

Breslav and Kalacheva (1980) investigated the operation of the human respiratory apparatus when breathing gas mixtures of different density under free conditions and with variable rates of air flow. Gas mixtures consisted of (1) ordinary air, (2) helium-oxygen mixtures, and (3) sulphur hexofluoride with oxygen. It was determined that the functional reserves of the respiratory apparatus are restricted when breathing a gas mixture with density significantly higher than atmospheric density. Lower-than-normal gas densities have no significant effect on respiration. The helium-oxygen gas mixture had little effect on respiration, while the sulphur hexofluoride-oxygen mixture significantly reduced the maximum ventilation of the lungs.

*Key words: compressed air, hyperoxia, physiological effects*

Gulyar (1980) investigated the physiological effects of breathing compressed air, with the accompanying hyperoxia, on circulatory, respiratory, and oxygen level dynamics. Divers were maintained at 2.5 kg-ft/cm<sup>2</sup> for 6 hr, and at 4 kg-ft/cm<sup>2</sup> for 2 hr. The effects consisted of an

increase in oxygen demand, respiratory volume, and respiratory dead space, as well as a decrease in the alveole-lung ventilation ratio. Hyperoxia promoted a decrease in the blood minute volume, stroke volume, and heart rate, while increasing total peripheral resistance. Concomitant with the increase in oxygen uptake and the resultant increase in its alveolar partial pressure, oxygen transport to the blood was decreased, leading to a lowering of arterial  $P_{O_2}$ . These changes are considered to reflect the adaption to inhalation of compressed air.

*Key words: external respiratory system, measures of fatigue, flight personnel*

Kamenskiy (1981) investigated the physiological mechanisms of fatigue as expressed through flight-related functional changes in the external respiratory systems of helicopter crews. With subjects divided into groups according to flying time per shift, pre- and postflight measures were made of vital lung capacity (VC), the pneumotometric index (PTI), and maximum breathing capacity (MBC). Individual subjective evaluations of fatigue were also elicited. VC showed virtually no change in any group. However, PTI and MBC changed as a function of length of flight. The greatest changes in these parameters were seen after 4 and 5 hrs, respectively (a decrease of 12% in each case). These changes roughly coincided with the appearance of subjective feelings of fatigue in the various groups (5 hr, 42.9%; 6 hr, 86.7%; 7 hr, 85.7%). The author speculates that noise and vibration played a substantial role in the decrease in MBC by impairing the mechanical stability of bronchial alveoli. The changes in PTI he attributes to general fatigue and the concomitant loss in strength of respiratory muscles. These findings lead to the suggestion that changes in MBC and PTI can be used to detect fatigue in flight personnel, and thus to assess their flight fitness.

## Cardiovascular System

*Key words: postural change, ventricular function, pulmonary circulation*

Chestukhin et al. (1981) examined the effects of orthostatic (70°, 15 min) and antiorthostatic (30°, 60 min) loads on left ventricular function and pulmonary circulation in healthy male subjects. The orthostatic load brought about a decrease in blood pressure of the pulmonary and femoral arteries, depressed the left ventricular end-diastolic pressure, and increased myocardial elasticity. Cardiac contractility was not affected, but an increase in the transpulmonary gradient of intravascular pressure was seen. Transition to the antiorthostatic position produced a marked increase in pulmonary artery pressure and end-diastolic pressure, while decreasing cardiac contractility and elasticity. After 1 hr in this position, cardiac contractility returned to normal. The other parameters mentioned remained unaltered, but heart rate and minute and stroke volumes increased.

*Key words: hypoxia, cardiac response, vascular response*

Krotov (1981) investigated changes in human hemodynamics, left ventricular contractility, and oxygen regime during exposure to acute hypoxia. Indicators of central hemodynamics and myocardial contractility were monitored by radioisotope methods while subjects breathed a gas mixture containing 11% oxygen before and after a 10-day period of daily exposures to simulated

altitudes of 5000 and 6500 m. Two types of immediate response to acute hypoxia corresponding to altitudes of approximately 5000 m were observed: a predominantly *cardiac* response characterized by increases in cardiac and systolic indexes, finite diastolic volume, and a decrease in general vascular tonus; and a predominantly *vascular* response characterized by decreased cardiac and systolic indexes, finite diastolic volume, and muscular and cutaneous blood flow, and increased peripheral resistance. In either case, the extent of the response is observed to be less marked following hypoxia training. The authors note that individuals exhibiting the vascular response appear to be more tolerant to sharply rarefied gas mixtures.

*Key words: myocardium, age-related changes, flight personnel, flight factors*

The functional capacities of man diminish with age. It is essential to better understand age-related differences in the reaction of flight personnel to flight factors. Vlasov and coworkers (1981) divided 72 aircraft crewmembers into 3 age groups: 18-25 years, 26-35 years, and 36-45 years. Each group included equal numbers of commanders, copilots, navigators, radio operators, flight engineers, and gunners. Electrocardiographic (EKG) and spatial vectorcardiographic (VEKG) measurements were taken before, 1-3 hr after, 12 hr after, and 24 hr after a 3-hr, low-altitude flight. EKGs showed an increase in duration of the P wave 1-3 hr after flight in the 36-45 year old age group. VEKG tests revealed an increase in angle between QRS and T vectors in space in the same group in the same time frame. No significant changes were seen in any other age group. The demonstrated changes in the older group did not exceed conventional norms, and were of no pathological significance. However, they do indicate some decline of adaptive capabilities of the myocardium with age, with respect to flight factors.

*Key words: emotional state, evaluation, slow wave, cardiac rhythm*

Heart rate (HR) has been the parameter of choice in aviation medicine for evaluating emotional states in pilots and other operators. In recent years, computer technology has made it possible to perform complex analyses of cardiac rhythm utilizing information contained in a series of cardiac cycles. Karpov and Zinov'yeva (1981) studied changes in slow waves of cardiac rhythm associated with exposure of operators to different emotogenic stimuli. Groups of subjects were exposed to slides with emotionally neutral content (controls) or content expected to elicit either sthenic (defensive) or asthenic ("imaginary death") emotional reactions. Concurrently, electrocardiograms (EKGs) and the galvanic skin reflex (GSR) were recorded. The amplitudes of first- and second-order slow waves (SW-1 and SW-2), as well as mean HR, were determined from the EKG readings. It was found that sthenic emotional reactions were associated with a sharp decrease in SW-1, while asthenic reactions produced an equally large increase in SW-1. In both cases there was an opposite change in SW-2. Both experimental groups showed an increase in the number of GSR waves (indicating emotion), while GSR decreased in the control group. HR was found to be the weakest indicator of emotional reaction. Thus, while GSR can indicate the development of emotion, the changes in slow waves of cardiac rhythm can be used to evaluate the degree and type of emotion present.



## Space Biology

### Hypokinesia

*Key words: adaptation, adrenal system, steroids, circadian rhythm, rhesus monkeys*

During prolonged exposure to weightlessness, reductions in muscle activity and strength trigger complex physiological and biochemical shifts. To further the understanding of the role of the hypophysis and adrenal system in adaptation, Tavadyan and Goncharov (1981a) examined circadian rhythms of hormonal activity in rhesus monkeys. Five male animals were subjected to horizontal hypokinesia in individual cages. The level of cortisol in the plasma dropped gradually during the day, to a minimum at 6-9 p.m., and then rose to a maximum at 6-9 a.m. Diurnal variation of precursors showed a similar pattern. Limited motor activity triggered a gradual reduction in mean daily concentration of steroids, although it did not affect circadian variation.

*Key words: adaptation, hypothalamo-pituitary-adrenal system, mice*

Changes in the hypothalamo-pituitary-adrenal system (HPAS) are known to be important in the adaptation to hypokinesia. Tsvetov, Razin, and Rychko (1975) examined the effects of 2 and 4 weeks of hypokinesia on the HPAS of 110 inbred mice. Progressive exhaustion was noted, accompanied by pathological reorganization of the HPAS morphofunctional structures of the animals. Known differences among animal species in the HPAS response to long-term immobilization allow the authors to suggest that an animal's response reaction depends largely on its HPAS resistance and the HPAS system's defensive adaptation potential.

*Key words: stress, testicular hormones, secretion, seasonal variation, rhesus monkeys*

Tavadyan and Goncharov (1981b) subjected male rhesus monkeys to prolonged (32-day) hypokinesia to study the stress-induced suppression of secretory activity of the sex glands. Separate experiments were conducted in the spring and fall to take account of seasonal variations in the animal's hormonal activity. Testosterone, stanolone, and luteinizing hormone were determined by radioimmunologic methods during the first 17 days of immobilization. Luteinizing hormone releasing factor was administered on Day 23 to evaluate hypophyseal gonadotropic function. Testicular sensitivity to gonadotropin was determined on Day 30 by the glands' reaction to luteinizing hormone and follicle-stimulating hormone. Results indicated a seasonal change in testicular hormone response to stress. The authors suggest that the suppression of hormone activity in sex glands is the result, not of impaired hypophyseal regulation, but of decreased glandular sensitivity to the tropic hormone.

**Key words:** *bioelectrical activity, catecholamines, melipramine, intermedin, rabbits, rats*

In experiments with rabbits and rats, Mel'nik and associates (1980) studied the bioelectrical activity and catecholamine balance of parts of the brain during hypokinesia with and without the use of psychotropic and hormonal agents such as melipramine and intermedin. They found that the use of these agents normalized the catecholamine balance and the functional state of hypothalamic nuclei (both impaired by hypokinesia).

**Key words:** *electrolyte concentrations, myocardium, hypothalamus, suprarenals, strophanthin, rabbits*

The effect of prolonged hypodynamia on the content of calcium, potassium, and chlorine in tissues of the myocardium, hypothalamus, and suprarenals of rabbits was studied by Reushkina and associates (1981). Control animals were kept in standard hutches. Two experimental groups were confined to special cages with movable walls that sharply restricted their activity. One of the two groups received strophanthin intravenously 1 day before and 7 days after the experiment began. By Day 30, all electrolyte concentrations in the myocardium and hypothalamus of the hypodynamic groups had dropped significantly; in suprarenal tissue only a tendency toward decrease was noted. Strophanthin had no effect on electrolyte redistribution. By Day 60, no further changes were seen in the hypothalamus. In the suprarenals, a more marked decrease in sodium concentration was found; potassium had increased somewhat, but not to normal levels. In the myocardium, a progressive decrease in potassium concentration was noted. The group that had received strophanthin, however, showed increased concentrations of all electrolytes in the myocardium, with potassium rising to control levels. Thus, the most marked disorders were found in myocardial tissue, with strophanthin exerting a positive, normalizing effect.

**Key words:** *dehydrogenase activity, pentose phosphate pathway, lipid metabolism, rats*

In order to determine the mechanism of metabolic disturbances under hypokinetic conditions, Lobova and Potapov (1981) studied the activity of dehydrogenase reactions of the pentose phosphate pathway (PPP) of carbohydrate breakdown in rats. Male animals were confined to small individual cages for periods of 7, 15, 30, 60, and 90 days. After 90 days, some animals were transferred to normal cages for readaptation. In the early stages of hypokinesia, the activity of glucose-6-phosphate and 6-phosphogluconate dehydrogenases decreased in adipose tissue (epididymal fat) and increased in the liver, skeletal muscles, and heart. On the 30th day, enzyme activity was nearly normal. Dehydrogenase activity increased again in adipose tissue by the 60th day, and by the 90th day in the liver and heart, although it decreased in skeletal muscle at that stage. During the readaptation period, the enzyme activity increased sharply in all tissues. A possible correlation between these changes in enzyme activity and disorders of lipid metabolism is explored. The authors propose that maintenance of high PPP dehydrogenase activity in hypokinesia, with a prevalence of catabolic processes, is essentially adaptive in nature—that it enhances the efficiency of reduction synthesis and, with the changeover to energy supply by fatty acids, allows a more economical use of glucose.

**Key words:** *weight-bearing bones, unloading, bone tissue, age factors, rats*

Animal studies conducted aboard the Cosmos-series biosatellites have demonstrated marked weightlessness-induced changes in weight-bearing skeletal bones (i.e., extremities and vertebrae). However, Cosmos rats were young animals (3 mos), in which bone formation and resorption develop at a faster rate than in adults. To investigate the possibility that bone reactions to the weightless state are age-dependent, Novikov and Ilyin (1981) suspended the rear extremities of rats of different ages in such a way that the hindlimbs did not bear weight or provide movement. Suspended rats, aged 1, 2.5, and 6 mos, were paired with control animals of the same age and weight which were kept in the vivarium. Femur length and width, thickness of the cortical layer, width of the bone marrow canal, and calcium content were measured after 22 days. The following table shows the results of the various measurements. It can be seen that the bone tissue of the 2.5-month group (closest in age to Cosmos rats) underwent the most change. This suggests that bone reactions of humans might vary according to age. Particularly in persons over 45, the increased rate of bone resorption could be a factor on longer flights.

**Cross-Section and Length Measurements of Femurs  
of Suspended Rats vs. Controls**

<u>Rat Group</u>	<u>Age in Months</u>	<u>Thickness of the Cortical Layer from Both Sides (Mean, mm)</u>	<u>Width of the Diaphysis (Mean, mm)</u>	<u>Width of the Bone Marrow Canal (Mean, mm)</u>	<u>Length of the Femur (Mean, mm)</u>	<u>Calcium Content</u>
Suspended	1.0	0.97 (-11%) <sup>a</sup>	3.49 (-7.2%)	2.52 (-5.6%)	31.19 (-4.3%)	(-17.3%)
Controls	1.0	1.09	3.76	2.67	32.63	
Suspended	2.5	0.73 (-28.6%)	3.67 (-2.7%)	2.87 (+12%)	33.27 (-3.5%)	No Change
Controls	2.5	1.02	3.68	2.66	34.48	
Suspended	6.0	1.56 (-10.9%)	4.45 (-3.1%)	2.89 (+1.8%)	40.5 (-1.6%)	(-9%)
Controls	6.0	1.75	4.59	2.84	41.2	

<sup>a</sup>Values in parentheses denote percent change from controls. Negative value indicates decrease; positive value indicates increase.

## **Radiation**

**Key words:** *radioprotective effects, immobilization, shielding, rats*

It has been demonstrated that immobilization of animals provides a degree of protection against death from radiation, probably as a result of adaptive processes such as the redistribution of cellular components of the blood and hemopoietic organs. Gronskeya and Strelin (1980) examined the extent of this protective effect in immobilized rats, with and without partial shielding of the bone

marrow. At a dose of 700 R, irradiation without binding or shielding led to an 80% fatality rate; binding (without shielding) allowed nearly all animals to survive. At a dose of 820 R, with immobilization, shielding of a small part of the bone marrow with a sublethal dose had no effect on survival rate; however, with shielding of a larger volume of the body the survival rate doubled. At a dose of 900 R all irradiated animals died, whether immobilized and/or shielded or not.

*Key words: linear energy transfer, dosage, protons, helium ions, skin lesions, mice*

Previous research has shown that the superficial (cutaneous) response to radiation is more severe under the effect of high-density ionizing particles with high linear energy transfer (LET) than under x- or gamma radiation. Little has been done to determine actual differences in effectiveness of heavy charged particles differing in LET on the skin of animals or man. Savchenko et al. (1981) measured the time-to-manifestation and severity of reaction of mouse skin exposed to various doses of x- and gamma radiation, protons with energies of 645 and 50 MeV, and accelerated helium ions (8 MeV/nucleon). They found that all but gamma radiation produced skin lesions. The severity of lesions depended on dosage and LET of radiation. Relative biological effectiveness (RBE) of X rays and of protons at both energies was close to 1.0 throughout the experiment and at all dosages (200 to 4000 rad). RBE of helium ions was 1.3 in the dose range 300-4000 rad. No reliable differences in time of formation of lesions were demonstrated.

## **Pharmacology**

*Key words: drugs, chemicals, reactivity, group factors, isolation*

Individual sensitivity to drugs and environmental chemicals is an area of medicine and biology that is not well understood. A book by Uzhdavini (1980) addresses problems of population physiology and their impact on pharmacology and toxicology. It discusses the process of formation of a group structure and the effects of group factors on animal resistance to chemicals. Morphological and physiological characteristics of individuals in a group play a large part in determining reactivity to chemicals, but supraorganismic group factors are capable of modifying reactivity. The special case of isolation is discussed as a means of studying the role of zoosocial influences. Data are also presented on changes in reactivity relating to functional state rather than to zoosocial factors. Practical problems of modeling in experimental biomedical research are discussed.

## **Metabolism**

*Key words: stress, fibrinolysis, ACTH, heparin, rats*

Kudryashov et al. (1977) investigated the role of altered hormonal status of an organism in the activation of the anticoagulative system during stress. Stress engendered in rats by 30 minutes of immobilization was shown to significantly increase the nonenzymatic fibrinolytic activity of blood. When combined with adrenocorticotrophic hormone (ACTH), the effect is even greater. Intravenous

administration of 0.2 ml of a 0.01% solution of protamine sulphate prevented the stress-induced nonenzymatic fibrinolysis. Administration of ACTH after protamine sulphate again increased fibrinolysis. This finding suggests that ACTH stimulates the release of heparin.

*Key words: hypoxia, hypercapnia, dehydrogenase activity, adaptation, rats*

The activity of lactate dehydrogenase in blood and tissue of the hearts of rats was studied during adaptation of the animals to hypoxia and hypercapnia of varying duration (Mikhalkina & Sverchkova, 1981). The study group included 72 white male rats weighing 150 to 250 grams. Hypoxia and hypercapnia were induced by placing the animals in a closed space for an average of 1.5 hr/day, in an atmosphere containing 10% O<sub>2</sub> and 3% CO<sub>2</sub>. Lactate dehydrogenase activity decreased during the first three days, then increased, with activity observed after 15 days of hypoxia and hypercapnia. After 30 days, dehydrogenase activity decreased once more, reaching the control value in blood serum taken from the heart. The study indicates that there is a specific adaptation of metabolic processes during 30 days of exposure to hypoxia and hypercapnia.

## Nutrition

*Key words: fistular feeding, soft diet, chyme production, dogs*

In recent years, research has shown that the composition of chyme at its exit from the gastroduodenal system is important in the assimilation of nutrients. Using dogs, Bryuzgina and coworkers (1981) examined the extent to which replacing oral intake of natural food with fistular injection into the stomach of a standard soft, gruel-like diet influences chyme formation in the gastroduodenal system and absorption of some ingredients in the small intestine. Chyme samples passing from the gastroduodenal system and distal part of the small intestine were assayed to determine changes in the content of sodium, potassium, calcium, magnesium, and both total and nonprotein nitrogen over a 6-hr period of digestion. In general, no change was found in the pattern of chyme production with the soft diet versus a normal diet: the general tendency in both cases was to preserve the composition of enteric contents. However, some differences were noted in the case of the soft diet which may affect the rate of digestion and absorption of chyme constituents. These differences were: (1) the concentration of sodium and total nitrogen did not increase between the 1st and 6th hours of digestion; (2) calcium concentration decreased; and (3) the concentration of total nitrogen in duodenal chyme was substantially higher.

## Respiratory System

*Key words: oxygen toxicity, pulmonary tissue, autonomic functions regulation, rabbits*

Various authors have stressed the leading role of the nervous system in the mechanism of development of the pulmonary form of oxygen toxicity. Aleksandrov and coworkers (1981) exposed rabbits to hyperoxic conditions to determine the nature of changes in their respiratory and cardiovascular systems. Oxygenation parameters were 2.5-3.0 kg/cm<sup>2</sup> for 3-4 hr and 2.0 kg/cm<sup>2</sup>

for 16-22 hr (until death). Physiological parameters recorded were heart rate, respiratory rate, respiratory volume, and minute volume of respiration. Serious changes were noted in all of these, in all animals. Lungs of rabbits that died or were sacrificed were used for histological examinations and to determine the surfactant stability index (SI). Morphological studies of lung tissue revealed that, in general, lungs of experimental animals did not differ either macroscopically or microscopically from those of control animals. Nor was there a significant difference in SI. Therefore, the authors conclude that the pathogenetic mechanisms of subacute oxygen intoxication are associated with disorders in the central regulation of autonomic functions rather than with direct lesions of the pulmonary tissue.

*Key words: gas density, hypoxia, muscle tissue, oxygen kinetics, rats*

Deep-water diving has directed attention to the effect of gas medium density on various physiological factors. Donina (1978) attempted to clarify conditions in gas exchange and oxygen supply to muscle tissue as a function of the density of an inspired gas mixture. Hypoxia was induced in rats using a variety of gas mixtures, and  $PO_2$  in muscle tissue was measured and correlated with physiological functions. Elimination times were recorded. Results showed that gas exchange decreased in hypoxia, and that the reaction to hypoxia depends on the density of the gas mixture. Free oxygen levels in muscle dropped immediately after inhalation of hypoxic mixtures. Oxygen diffusion varied as a function of gas molecular size. Thus, inert gases were shown to affect oxygen kinetics.

### **Cardiovascular System**

*Key words: simulated weightlessness, cardiovascular effects, growth of tumors, rats*

In recent years there have been reports of a correlation between state of the cardiovascular system and growth of malignant tumors. This has a possible bearing on spaceflight, with its attendant cardiovascular deconditioning. Medical screening techniques cannot guarantee that a cosmonaut/astronaut candidate is free of asymptomatic disposition for neoplasms, or even a minimal blastoma. To study the growth of malignant neoplasms under spaceflight conditions, Rudenko (1981) simulated the cardiovascular effects of weightlessness by inducing prolonged arterial hypotension in rats. Constriction of the abdominal aorta below the renal arteries produced an average drop of 40% in arterial pressure of the posterior portions of the animals' bodies. Experiments were conducted to determine: (1) probability of formation of tumor, based on percentage of successful transfer of sarcoma 45; (2) tumor growth rate; and (3) survival time after transfer of Walker's carcinosarcoma. It was found that the diminished vessel stretch loads due to hypotension produced a lower probability of tumor onset (because capillary growth was impeded). Blastoma growth was also affected: the tumor remained less than half as large in experimental animals as in controls. Lastly, the survival time of experimental animals with Walker's carcinoma was nearly double that of controls. The author concludes that long-term exposure to weightlessness does not present a greater risk of neoplastic pathology.

### Bioinstrumentation

*Key words: dynamic blood measurement, flowmeters, flow sensors*

An article by Barinberg and Barinberg (1979) reviews developments in blood measurement techniques. Currently, the most widely used instrument is the magnetohydrodynamic flowmeter (MHD-flowmeter). One recently developed version of this instrument makes it possible to take readings with an accuracy of 1.5%. Noninvasive cuff-type flowmeters are another recent innovation. Implanted flow sensors, including a catheter-type sensor, increase the range of measurement sites. A multichannel system using MHD-flowmeters has been designed for recording cardiac and vascular parameters in space, although, as of the time of writing, it had not been used in space.

*Key words: hypoxia, oxygen consumption, sensing technique*

Popov (1980) devised a method for determining oxygen consumption by laboratory animals under reduced barometric pressure, using a monometric oxygen consumption sensor. With an experimental animal held at a simulated altitude of 9,000 meters, oxygen consumption decreased—especially during the first 10 minutes. Gas metabolism varied over time, with a strong initial decrease in oxygen consumption being followed by an increase approaching initial values toward the end of hypoxia. During the first 10-20 minutes posthypoxia, oxygen consumption increased above initial values.

### Toxicology

*Key words: water regeneration, sorption, reducing agent, peroxides, toxicological tests*

The sorption method of water regeneration used aboard the Soviet Salyut-series orbital stations yielded high-grade, non-toxic potable water from the condensation of atmospheric humidity aboard the stations. However, moisture-containing emissions produced by onboard technical equipment and processes may contain a variety of harmful chemicals, including oxidants and oxidation products, that are not effectively removed by the sorption method alone. Pak et al. (1981) performed sanitary-chemical and toxicological analyses of water reclaimed from recycled fluid containing peroxides. Two methods of regeneration were used: the standard sorption technique, and sorption with a reducing agent added to the charge. The hygienic tests consisted of conventional physicochemical assays. A battery of toxicological tests were carried out with fish, daphnia, frogs, and rats. The sanitary-chemical tests rated both regenerated water samples as potable. The toxicological studies, however, revealed that the sample recovered without the use of reducing agents had a marked toxic effect on all the life forms tested. Numerous physiological function changes or disruptions were seen, along with tissue changes in rats. The fish and protozoa died. The authors suggest that toxicological studies should be the final stage in evaluation of reclaimed drinking water.

*Key words: metabolic gases, atmospheric pollution, altered concentrations, toxicological evaluation*

Savina and Kuznetsova (1980) examined the extent that human metabolic products contribute to the pollution of the air environment in a confined space. Toxic impurities present in gaseous exhalation and intestinal gases as well as evaporative products of perspiration and urine were calculated. A particular focus was on the effect that such factors as altered microclimate, unusual diet, fasting, and antiorthostatic hypokinesia have on the composition of exhaled air. It was found that fasting and worsening of microclimate with respect to temperature and humidity have the largest effect. The authors used their findings as the basis for selecting those pollutants which have a concentration that is both significant and subject to alteration, and which can thus be used to assess the hygienic and toxicological status of the air environment of pressurized enclosures.

*Key words: nitrogen, oxygen, helium, higher nervous activity, adaptation*

Using divers as subjects, Gulya and associates (1978) studied the effect of partial nitrogen pressure at subnarcotic concentrations (5 and 12 kg/cm<sup>2</sup>) on higher nervous activity. Of particular interest were the value of preliminary adaptation and the effect on intellectual work capacity. It was found that, at 5 kg/cm<sup>2</sup>, with comfortable temperature and humidity, results of a proofreading test improved and number recall was slightly impaired. However, when temperature and humidity were elevated, scores were greatly reduced; sensory motor reactions and coordination were also affected. Psychological state was progressively worsened: after a week, irritability and decreased motivation were seen; after 11-14 days, sleep disturbances and a decline in test performance were noted. Error rates were higher at greater nitrogen pressure. Experiments carried out indicate that preliminary adaptation increases the depth limits for use of nitrogen-oxygen mixtures, and that elevated partial oxygen pressure has a negative effect on central nervous system activity. This effect appears to be more pronounced in nitrogen than in helium.

*Key words: pure nitrogen, hypoventilation, reserve time*

Pure-nitrogen breathing is used to simulate breathing conditions encountered following the decompression of spacecraft cabins. Katkov and Kovalenko (1981) investigated the use of voluntary hypoventilation as a means of prolonging reserve time (time of useful consciousness) under these conditions. Nitrogen breathing tolerance times as well as respiratory and circulatory parameters were determined in control subjects breathing nitrogen normally or slowly. Experimental subjects breathed nitrogen normally or slowly both before and after a 10-day period of hypoventilatory training on pure nitrogen. Training was found to increase reserve time from about 70 sec to 140-160 sec. This effect is attributed to the elevation of the breathing center's threshold of sensitivity to hypoxic and hypercapnic stimuli, allowing oxygen losses to be slowed. Hypoventilation during nitrogen breathing was also found to be accompanied by a marked decrease in skin oxygen tension relative to normal breathing under these conditions. This is attributed to increased blood flow to the brain and heart at the expense of peripheral regions.



## Closed Life Support

*Key words: biological life support, algal culture*

In space missions of medium duration (1 month to 1.0-1.5 years), an economical life support system should provide for the regeneration of water from atmospheric moisture and human liquid wastes by physicochemical means. Longer-term missions (1.5-2 years) require the addition of  $O_2$  regeneration. However, when mission length exceeds 2 years (this includes continuously manned orbiting stations), a biological life support system (BLSS) is required for the production of food, in addition to oxygen and water. In a chapter of their book *Activity of a Photosynthesizing Culture of Microalgae*, Belyamin, Sid'ko, and Trenkenshu (1980) examine in detail the requirements of a biotechnological system based on photobiosynthesis of algae. The authors designed and tested an experimental two-component BLSS system (man and microalgae) that is self-regulating and self-stabilizing, using human  $CO_2$  gas exchange rate as the limiting factor on productivity. Human trophoenergetics, photoenergetics of cultures of different species of microalgae, and mass transfer parameters related to energy transfer between the two components are expressed mathematically.

*Key words: human waste, synthetic carbohydrates, organic acids, yeast cultivation*

Physicochemical methods of converting human waste into assimilable foodstuffs in a closed life support system hold some promise. Sinyak and Shul'gina (1981) tested the feasibility of obtaining organic acids from monosaccharide racemates condensed from formaldehyde according to the following process: human waste  $\rightarrow$  carbon dioxide  $\rightarrow$  methane  $\rightarrow$  formaldehyde  $\rightarrow$  synthetic carbohydrates. The carbohydrates (monosaccharides) are converted into organic acids through the Cannizzaro reaction; different combinations of acids are obtained in different atmospheres. Acids were recovered from natural monosaccharides (e.g., fructose, glucose) as a control. When biological evaluation of the synthetic organic acids was carried out through cultivation of yeast, data revealed an intensive growth of the species *Candida tropicalis* CK-4. Yeast cultivation could provide a valuable source of food protein aboard a spacecraft.

*Key words: reclaimed water, enrichment, water quality, conductometer*

Water regenerated from wastes is similar to distilled water, in that it is lacking in minerals and certain organoleptic properties. To improve taste, such water is usually enriched by the addition of macro- and trace elements (calcium, magnesium, fluorine, iodine, chlorides, sulfates, etc.). It is necessary to monitor and evaluate the quality of mineral composition of water produced by such methods. Chizhov et al. (1981) used a conductometer to demonstrate the correlation between specific electrical conductivity and indicators of dry residue and hardness of water enriched with macrominerals and trace elements by a variety of methods. They found that each method of enrichment presents characteristic group coefficients of mineralization that can be calculated in relation to electrical conductivity. Thus, the conductometer is an effective instrument for assessing water quality.

## Exobiology

*Key words: origin of life, extraterrestrial life*

A special issue of the *Journal of the All-Union Chemical Society Imeni D.I. Mendeleyev* (Knunyants, 1980) contained articles dealing with the origin of life from several points of view (chemical, biochemical, genetic, evolutionary, cybernetic, physical, biological, etc.). Articles of particular interest from the standpoint of space biology include: "Space Factors of Origin and Development of Life and Intelligence in the Universe"; "Is There and Was There Life on Mars?"; "Cosmic Vacuum Prevents Spontaneous Migration of Microorganisms in the Universe"; "Origin and Evolution of Nucleic Acids"; "The Universe as a Self-Organizing Cybernetic System"; and "Strategy of the Search for Extraterrestrial Civilizations."

## SPACEFLIGHT RESULTS

### Space Medicine and Physiology

#### Mission Reviews

*Key words: manned missions, achievements in space medicine*

In a review of Soviet progress and achievements in manned spaceflight, published to commemorate the 1961 flight of Gagarin, N.N. Gurovskiy and A.D. Yegorov (1981) examined the development of the field of space medicine, discoveries that have been made, and prospects for future advancements of knowledge. The authors discuss the historical development of the field as consisting, thus far, of three stages: (1) the preparatory stage, in which essential questions regarding the survivability of man in space and the requirements for life support were solved; (2) the decade of short-term manned flights (1961-1970), in which problems of man's adaptation to spaceflight conditions were identified and attacked, and (3) the decade of long-term flights aboard orbital stations (1971-1980), in which a primary focus was on prevention of the adverse effects of weightlessness. Important areas of concern in space medicine and biology (medical monitoring and inflight studies, preventive measures, and changes in human vital functions) are discussed in some detail.

*Key words: spaceflight, adverse effects, review*

A paper by Gazenko, Genin, and Yegorov (1981) reviews studies on the effects of weightlessness, vestibular disturbances, and disturbances of the cardiovascular and motor systems among Soviet cosmonauts, particularly on prolonged flights. Results of these studies show that physiological disturbances manifested in short-term flights (one month or less) present no problem for longer-term flights (up to six months) if proper conditions of exercise, work, and life support are maintained.

*Key words: space biology and medicine, bibliography*

A book by Sergeev (1980), the third in a series of bibliographic volumes, presents a compilation of nearly 4000 works in the fields of aviation, space, and high-altitude biology and medicine published in the Soviet Union from 1972 through 1976. Specific areas considered include hypoxia and altitude adaptation, biological rhythms in pilots and cosmonauts, vibration, motion sickness, inflight emergencies, nutrition, pilot and cosmonaut selection, hygiene, hypokinesia, hypoxia, decompression sickness, the effects of lowered atmospheric pressures, weightlessness, operator activity, pharmacology, psychology and psychophysiology, radiobiology, thermoregulation, acceleration loads, and the vestibular apparatus.

## Cardiovascular System

*Key words: 140-day flight, cardiovascular parameters, inflight physical training*

During the 140-day Soyuz 29/Salyut-6 mission, crewmembers V.V. Kovalenok and A.S. Ivanchenko performed exercise tests on a bicycle ergometer, during which heart rate, before-after arterial pressure, left ventricular chronograms, and circadian output were recorded. Gazenko et al. (1981) analyzed these data as part of the continuing effort to study human adaptation to long-term weightlessness, particularly in view of the more extensive use of preflight physical conditioning. They found that, in comparison to preflight test results, inflight test results showed less expressed changes in phasic parameters, only moderate increases (above preflight) in cardiac output, and, occasionally, insufficient decrease in peripheral resistance. The authors attributed these changes to the deficiency in circulating blood volume caused by weightlessness. However, circulatory parameters revealed no overt signs of physical deconditioning inflight; this is attributed to the intensive inflight physical training program.

*Key words: cerebral circulatory system, functional steadiness, altered gravitational conditions*

Moskalenko (1981) introduces the concept of *functional steadiness* of the cerebral circulatory system. This is described as an integrated capability, developed during evolution in gravity, by which the system can fulfill its functional tasks under different external loads, including positional changes in the gravitational field. Studies have shown that this functional steadiness of the cerebral vascular system is based on a complex physiological mechanism which includes mechanical, myogenic, metabolic, and neurogenic links of regulation. The author proposes that the altered gravitational conditions of spaceflight not only influence cerebral blood flow directly, through interactions with central hemodynamic parameters, but also cause indirect changes in functional steadiness through changes in the level of activity associated with these links of regulation. Rheoencephalographic data obtained during the Salyut-4 mission were subjected to analysis to detect changes in functional steadiness under functional load. Changes in some parameters were determined to be significant.

## Musculoskeletal System

*Key words: osseous tissue, biochemistry, spaceflight factors*

A review of the 1977 book *Functional Biochemistry of Bone Tissue*, by Torbenko and Kasavina (1981) was received. The work deals with metabolic activity of bone cells, composition of the organic matrix of osseous tissue, and the composition and structure of mineral components. Spaceflight factors have an appreciable effect on osseous tissue; long-term immobility, for example, can lead to unbalanced mineral metabolism, loss of skeletal calcium, and development of osteoporosis. The effects on bone of this and other factors of the space environment are discussed in detail. Age-related changes and the role of nutrition are also discussed.

## Hematology and Immunology

*Key words: immunoreactivity, spaceflight conditions, atmospheric pollution*

Konstantinova and Antröpova (1980) examined changes in human immunoreactivity that occur in a confined environment under (a) standard hygienic conditions of the microclimate and (b) varying degrees of pollution of the air environment by trace impurities of a chemical and biological nature. Data were derived from spaceflights of varying duration. It was shown that, over long-term space missions (30-140 days), microclimate alterations elicit a number of changes in cosmonaut immunoreactivity. Functional changes in the immunological system lead to a diminished functioning of T lymphocytes, changes in the levels of different subpopulations of immunocompetent lymphocytes and immunoglobins of the G and A classes, sensitization to bacterial allergens, and activation of autoimmune processes. Brief-duration spaceflights (6-8 days) do not have an appreciable effect on human immunological reactivity.

## Microbiology

*Key words: bifidoflora, stressors, spaceflight*

The population of human intestinal microflora is affected by changes in diet and exposure to stressors such as isolation. Bifidobacteria show the most rapid and sensitive reactions. Changes in bifidoflora reflect the very earliest stages in intestinal microbiocenosis in response to extreme factors, occurring long before clinical manifestations appear. Goncharova et al (1981) examined the state of bifidoflora in eight cosmonauts before and after spaceflights of varying durations (5-8 day Soyuz orbital flights and 30- and 63-day Salyut missions). In the 45-day period before launch, and particularly just prior to launch, bifidoflora decreased drastically in all subjects. Postflight results were mixed: bifidoflora had increased to preflight values in some cosmonauts, to higher levels in others, and remained the same in one. Preflight results are attributed to nervous and emotional tension. The higher-than-normal levels (in the 63-day flight crew) are said to be related to the use of onboard preventive measures such as vitamin and amino acid supplements. Species composition of bifidoflora remained stable.

*Key words: intestinal microflora, dysbacteriosis, countermeasures*

An article by Shilov and Liz'ko (1980) summarizes their previous research on intestinal microflora of cosmonauts and other individuals isolated in a confined space. Both the positive and the potentially negative role of these microorganisms are dealt with. Methods of normalizing the intestinal microflora of cosmonauts during space missions are discussed in connection with the development of dysbacteriosis under the influence of extreme environmental factors.

*Key words: cosmonaut microflora, mechanism of transmission, spaceflight environment*

It is likely that a source of diseases appearing in cosmonauts would be the pathogenicity of their own microflora. To further define the associated risk, Zaloguyev et. al. (1980) studied changes in expression of the mechanism of transmission of microorganisms under conditions that prevail in the spaceflight living environment. It was found that there are increases on cosmonaut integumental tissues in the number of staphylococci, hemolytic streptococci, and various bacillary and fungal flora. A comprehensive study of the staphylococcal flora revealed that there is a periodic increase in the number of staphylococci with pathogenic traits and high resistance to antibiotics. Given the increased intensity with which these microorganisms are released into the space cabin environment, there is a significant risk of infection among cosmonauts. The air environment is the principal medium of transmission, with internal cabin surfaces playing an important part. The authors conclude that there is faster expression of the mechanism of transmission of microorganisms under these conditions than on Earth.

## **Psychology**

*Key words: man-machine system, human reliability, psychophysiological aspects, optimization*

The degree of responsibility man holds in manned spaceflight, both as a component of semi-automatic onboard control systems and as an independent element of the overall mission, has increased with the increasing complexity of space technology and space research. Reliability of the "human component" is thus an increasingly important issue. Beregovoy and Khachatur'yants (1981) compiled a book dealing with theoretical and practical problems of improving space crew efficiency. This book is the fourth in a series dealing with the subject of engineering psychology relative to spaceflight; it is the first in the series to discuss specific methods of optimizing safety and elements of cosmonaut work and mental functioning. Separate sections include articles dealing with: (1) forecasting and optimizing training and psychophysiological performance; (2) optimizing performance as part of the spacecraft control system; (3) solving technical problems in system maintenance and EVA; (4) optimizing resistance to stressors.

*Key words: weightlessness, psychological response, acclimatization training*

Kitayev-Smyk (1981) reviewed the psychological aspects of the initial response of humans to the experience of weightlessness. Subjects can be classified into one of three categories: (1) those who display panic reactions, with violent motor activity; (2) those who experience unpleasant sensations but no panic; and (3) those who seem to adapt easily and immediately. Very few subjects "fall" into the latter category, but most can be trained to show this response. The author discusses methods of training subjects to become accustomed to weightlessness. Some well-known Soviet cosmonauts and pilots are classified as to initial-reaction category.

## **Radiation Effects and Protection**

*Key words: cosmic rays, hazard forecasting, radiovulnerability, radioprotective factors*

In a book entitled *Mutagenesis Induced by Physical Factors*, a chapter by Miroshnichenko (1980) reviews findings regarding the effects of cosmic rays on biological systems. One focus is on the degrees of hazard presented to space crews by radiation of galactic origin, from solar flares, and from the radiation belts. The composition of such radiation and its distribution over time are discussed. Progress in methods of evaluating and forecasting radiation effects is reviewed. Such methods are becoming increasingly important with the prospect of frequent long-term habitation of spacecraft (or colonization of space) and use of plants in a closed life support system. Yearly radiation dosage estimates are projected under various conditions of shielding. Certain organ systems (e.g., bone marrow and gastrointestinal tract) are more radiovulnerable than others. On this basis, the probability of survival that results with shielding of various portions of the human body is examined. Mutagenic effects of radiation exposure of animals, microorganisms, and plants during stratospheric and orbital flights are also discussed. The author emphasizes that, on the basis of relative risks, preference should be given to studies of radiation damage effects rather than genetic hazards.

## **Clinical Aspects of Crew Health**

*Key words: prognostication, borderline health states, adaptation, regulation*

The forecasting or prognostication of changes in the health status of individuals when exposed to diverse environmental factors is currently receiving attention in medicine in general, and in Soviet space medicine in particular. A book by R.M. Bayevskiy (1981) attempts to shed light on this subject by describing and classifying functional changes that characterize certain borderline or "prenosological" states intermediate between health and disease, and by presenting methods for prognostic evaluation of such states. These forecasting techniques are based on the concept that adaptation to the environment (an adaptation which begins with energy mechanisms on the cellular level) places a strain on regulatory systems of the body. The "price" of the adaptation reaction is thus an incremental lessening of health status. The author conceives of such incremental steps as qualitative "microjumps" preceding the "macrojump" from normal to pathological state. Using parameters of the cardiovascular system—particularly cardiac rhythm—as indicators, the author performs various mathematical analyses that produce data regarding the degree of strain on regulatory mechanisms and functional reserve. Other forecasting techniques include use of the phase plan method and circadian rhythms. Special sections of the book dealing with the prediction of physical capacity and mental efficiency are of particular interest in the context of spaceflight; these are based on the author's own research in support of space missions.

## Space Biology

### Mission Reviews

*Key words: gravitational biology, vital processes*

A review article by Il'in (no date) examines the results of gravitational biology experiments conducted by the Institute of Biomedical Problems aboard Cosmos biosatellites and in ground-based laboratories. Over the years, subject organisms have included bacteria; cell cultures (plant and animal); insects; ova and embryos of fish, birds, and rats; higher plants; and mammals (monkeys and rats). Ground-based experiments have used clinostats and centrifuges to simulate the weightlessness of space. The general objective of these studies has been to increase our understanding of the functional significance of gravity in biological processes. In addition to the purely scientific value of the findings, it is of great practical importance to know whether there are vital processes that present a "biological barrier" to prolonged exposure of humans to weightlessness, and whether measures can be developed to eliminate or extend such barriers. Some general conclusions of this research are: (1) Gravity does not affect cells or intracellular processes in bacteria, due to their small size ( $<10\ \mu\text{m}$ ). (2) Gravity does not affect intracellular division or the cell genetic system. (3) Gravity does not affect development of fertilized eggs of the centrolecithal type. (4) Gravity is not necessary for normal activity of vital functions, at least in lower organisms. (5) Gravity *does* affect processes that are related to density gradients in cells and tissues, such as are found in plant growth and development of fertilized telolecithal eggs. (6) Functional systems containing receptors that react to changes in magnitude or direction of gravity, as well as those that are evolutionarily adapted to supporting body weight (musculoskeletal system) or body parts (cardiovascular system) are gravity-dependent.

### Musculoskeletal System

*Key words: soleus muscle, morphology, deconditioning, circulation disorders, rats*

Weightlessness is known to cause atrophy of skeletal muscles. Experiments conducted on rats aboard Cosmos biosatellites have shown that, of the antigravity muscles of the hind limbs, the soleus muscle is the most affected. A number of specific functional and metabolic changes related to structural changes in this muscle have been demonstrated. Using ground-based controls (hypokinesia) for comparison with data from four biosatellites, Il'ina-Kakuyeva and Portugalov (1981) sought to explain the observed morphological changes. They proposed that focal edema and dystrophic changes observed in experimental and control animals are caused by circulation disorders of different etiology. In flight rats they resulted from the deconditioning of muscle tissue and the intraorgan vascular system, while in hypokinetic rats circulation disorders resulted from mechanical causes (continuous pressure on the paws) and muscle pump deficiency. It was reported that, in all cases, circulation disorders seem to be associated with peculiar features of the angio-architectonics of the soleus muscle.



## Metabolism

*Key words: stress, catecholamines, enzyme activity, myocardium, Cosmos 782, rats*

Immobilization studies have shown that acute stress causes a decline in the catecholamine (CA) content of the myocardium of rats. Subsequent adaptation to stress involves an increase in CA synthesis, so that CA concentration stabilizes. To assess the stressor effects of long-term spaceflight on rats, Kvetnyanski and Tigranyan (1981) measured the concentration of catecholamines and the activity of enzymes involved in both CA synthesis and degradation in the myocardium of rats flown for 19.5 days aboard Cosmos 782, as well as in synchronous and vivarium control rats. Animals were decapitated either immediately or 26 days after completion of the experiments. Expected results would be either a decrease or no change in CA concentration, due to stress or adaptation to stress. However, the researchers found a significantly *elevated* level of myocardial CA postflight, with enzyme activity remaining unchanged. Possible explanations are an increased absorption or diminished elimination of CA, altered properties of receptors, or some other manifestation of a functional change in the sympathetic nervous system or the heart. The authors conclude that long-term spaceflight is not a stress-producing factor for rats.

## Microbiology

*Key words: cell reproduction, cell growth, Salyut 6, paramecia*

Tixador and coworkers (1981) describe experiments they prepared and which were performed onboard the orbiting Salyut 6 station in order to investigate the proliferative capacity of unicellular organisms in zero G. In these experiments, known as the CYTOS program, cultures of *Paramecium tetraurelia* contained in an incubator were fixed at prescribed intervals over a 4-day period. Identical controls were maintained on Earth. Findings included the following: (1) cell population was larger in the inflight cultures; (2) mean cell volume of experimental cells was larger; and (3) dry weight and mean total protein content of the inflight cells were smaller than in the control cultures. The authors describe specialized culture chambers and incubators they developed to house the cultures under controlled conditions for growth and to permit simple, semiautomatic fixation by the Salyut flight crew.

*Key words: small intestine, ultrastructure, spaceflight factors, Cosmos 936, rats*

Spaceflight factors have been shown to induce significant and persistent changes in human and animal digestive systems, particularly in the small intestine. Earlier light optic examination of rats flown on biosatellites did not show appreciable structural disturbances of the small intestine due to spaceflight factors; but substantial changes in its membrane structures were found through electron microscopy. Yakovleva and colleagues (1981) performed similar examinations of small intestines of rats flown aboard Cosmos 936. Experimental conditions were the same here as in the previous studies, except that one group of flight animals was subjected to artificial gravity via centrifuge. Ultrastructural changes found in the earlier studies were again seen in all experimental

groups (including synchronous groups on the ground). Changes consisted of destruction of enterocytic microvilli and accumulation of lipid droplets, fragmentation of the basal sections of most enterocytes, and tapering of epithelial cells on the lateral surfaces of the villi. Artificial gravity did not have a significant effect on the direction of change; changes were somewhat less marked in the synchronous ground-based group, however, and recovery was more rapid. It was therefore concluded that the observed changes are morphological manifestations of the reaction of intestinal tissue to the combined effect of all spaceflight factors.

*Key words: growth, ultrastructural organization, nutrient medium, Proteus vulgaris*

The book *Space Research in the Ukraine* (Pisarenko et al., 1978) presents articles dealing with many aspects of space research, including materials processing and inflight plant and animal studies. Three articles concern *Proteus vulgaris* bacteria, its patterns of growth, ultrastructural organization, and variations in nutrient medium under spaceflight conditions. These studies are discussed individually on page 22 of the 1980 *Annual Summary* of the Life Sciences Digest.

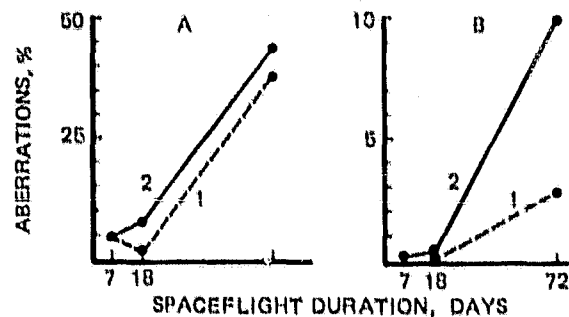
### **Radiation Effects and Protection**

*Key words: cosmic radiation, dosage, flux, energy spectra*

The Institute of Biomedical Problems (1980) published the results of experiments conducted aboard the Cosmos-1129 biosatellite to study characteristics of cosmic radiation (CR). Objectives were to investigate the dose characteristics of CR under thin shields and to measure the flux and spectra of CR heavy nuclei and neutrons. Thermoluminescent detectors were placed inside containers under varying degrees of shielding (0.0035 to 10 g/cm<sup>2</sup>). One container was kept inside the biosatellite, and four were mounted on its exterior. Of particular interest were data on dose distribution beyond layers of shielding less than 0.5 g/cm<sup>2</sup> in thickness. Results indicated that, in a layer 0.02 g/cm<sup>2</sup> thick of shielding of 0.00346 g/cm<sup>2</sup>, the superficial dose over 20 days was 2500 rad (125 rad/day). Increasing the thickness of the shield reduced dosage dramatically. For example, the dose beyond a screen 1 g/cm<sup>2</sup> thick was about 0.5 rad. This sharp fall-off is due to the predominance of the "soft" component of cosmic radiation. Dielectric track detectors were employed to measure the flux and spectra of linear energy transfer (LET) of heavy nuclei of CR. Readings of flux were one-half to one-third as large as on previous missions under identical conditions, possibly because the current measurements were taken during a period of maximum solar activity. An equation is derived for estimating LET spectra under the experimental conditions. Neutron flux was measured with improved precision by means of alternating foil and phosphate glass. The spectrum of high-energy neutrons was reconstructed from the energy spectrum of recoil protons formed by neutron scatter over a photographic emulsion. The energy spectrum was considerably softer inside the craft than outside, although maximum distribution values were referable to about the same range of neutron energy (3-5 MeV). Integration of the spectrum resulted in a neutron flux of  $1.7 \times 10^6$  neutr/cm<sup>2</sup> inside and  $2.1 \times 10^6$  neutr/cm<sup>3</sup> outside the satellite.

*Key words: mutagenesis, heavy ions, spaceflight factors*

An article by E.N. Vaulina (1990) from the book *Mutagenesis Induced by Physical Factors* discusses mutagenesis caused by a variety of spaceflight factors, including weightlessness, acceleration, noise, vibration, and spacecraft environmental characteristics. Prominent treatment is given to the mutagenic activity of radiation. Radiation absorbed by life forms in a spacecraft consists of galactic cosmic radiation, radiation from solar flares and the Earth's radiation belts, radiation from onboard equipment, and secondary radiation produced by the collision of heavy charged particles with the spacecraft itself. Of these, cosmic rays are of the most interest to radiation biologists since their biological effects are the least well understood, the most difficult to study, and potentially the most damaging. It has been shown that the effect on mammalian cells of an accelerated heavy ion is about 1,000 times greater than that of its low-density ionizing analogue with low linear energy transfer. Heavy ions induce a larger area of damage per particle, and the damage is far more persistent. Multiple lesions in cell chromosomes are induced by heavy ions, and radioprotective agents are not effective against them. The figure shows aberrations induced in seed cells by heavy ions, as compared to gamma radiation. It is emphasized that radiation occurs in conjunction with other spaceflight factors that modify its effects, and whose effects it modifies in turn.



Incidence of cells with single (A) and multiple (B) aberrations as a function of spaceflight duration

- (1) Control: seeds exposed to 3 krad gamma rays  
(2) Experimental: seeds exposed to spaceflight and preflight gamma radiation in a dosage of 3 krad.

*Key words: chromosome loss, non-disjunction, gamma irradiation, spaceflight dynamic factors, Drosophila*

Kogan and Grozdova (1981) studied the frequency of chromosome loss and appearance of recessive lethals when the modifying effects of spaceflight dynamic factors (acceleration, vibration, etc.) are present in combination with ionizing radiation. Primary chromosomal non-disjunction and loss were computed in irradiated and nonirradiated (control) *Drosophila melanogaster* oocytes (stages 7 and 14). It was found that dynamic factors increased the frequency of primary non-disjunction in experimental oocytes, compared to controls. X-chromosome loss in irradiated oocytes was the same whether dynamic factors were present or not. Results were the same for mature and immature oocytes. The authors suggest that dynamic factors lower the probability that radiation damage will be repaired before chromosome breaks occur, and are associated with suppression of repair to primary single-strand lesions.

## **Plant Research**

*Key words: spaceflight factors, growth, reproduction, tissue cultures, seeds*

The book *Space Research in the Ukraine* (Pisarenko et al., 1978) presents, in addition to a review of materials science and animal experiments, a number of articles dealing with plant research conducted aboard various biosatellites of the Cosmos series. Subject organisms in these studies include fungi, higher plant tissue cultures, dill seeds, and duckweed turions. Growth and reproduction in weightlessness and under conditions of light and dark, irradiation, and different culture media were investigated. These studies are discussed individually on pages 20-21 of the 1980 *Annual Summary* of the Life Sciences Digest.

## **Life Sciences Technology**

### **Space Cabin Environment**

*Key words: sanitation, hygiene, human physiology, aeroions, pressurized environment*

A book edited by Yu.G. Nefedov (1980) focuses on the current status and prospects for solving some of the sanitary-hygienic and physiological aspects of the problem of habitability of manned spacecraft. Articles concerned with the toxicological evaluation of sources of pollution of the air environment, with human immunoreactivity in a confined environment, and with the possibility of pathogenicity and cross-infection of cosmonauts by their own microflora are discussed elsewhere in this report (see "Toxicology," "Hematology and Immunology," and "Microbiology"—Space Medicine and Physiology). Other articles deal with toxicologic/hygienic considerations relating to the outgassing of polymers and their "bioresistance" potential, and to the presence of aeroions. The need to regulate both the concentration of light aeroions (which are potentially more hazardous in weightlessness) and the coefficient of unipolarity is explored. In addition, there is a discussion of the functional state of different physiological systems of man as a function of parameters of the environment in a pressurized habitat.

*Key words: Russian bath, onboard facility*

The book *The Soothing Heat*, by A. Galitsky (1981) makes reference to the fact that, upon completion of their 175-day Soyuz 6 mission, one of the first requests of cosmonauts Lyakhov and Ryumin was to take a Russian bath. Historical and physiological aspects of this type of bath are discussed. Provisions for providing cosmonauts with onboard facilities for taking Russian baths during future space missions are described.

## Exobiology

*Key words: weightlessness, extension of life, closed life support, "Noah's Ark"*

In an article on the prospects for extending terrestrial biology into space, O.G. Gazenko and associates (1981) review the results of biological experimentation in space and speculate on their meaning in terms of the origin and propagation of life. The current state of our knowledge and conjecture regarding prebiological (chemical) evolution in interstellar space and the beginnings of biological evolution on Earth is adduced to bring a broader philosophical scope to the discussion. Numerous studies in space with microorganisms, plant and animal tissue cultures, seeds, embryos, and adults have shown that—for smaller organisms, at least—weightlessness has no detectable influence on reproduction, morphology, anatomy, biochemistry, or even behavior. Studies of higher plants have been more problematical because, being unable to regulate their internal processes in response to sudden changes in the environment, they require more precise control of environmental conditions than has heretofore been possible. Thus, the outlook for creation of a stable, entirely autonomous ecologic system including man is at present one of "defined optimism." Of the three processes required for the establishment and evolution of such a system—heredity, mutability, and natural selection—the first two appear to operate normally in weightlessness. That fact offers to man the possibility of being in space with his "Noah's Ark" long enough to find the conditions necessary to support the third.

*Key words: nucleosides, abiogenetic synthesis, "Meduza," Salyut 6*

Kuzicheva (1981) reports on the results of the "Meduza" experiment carried out aboard the Salyut 6 station. The purpose of this experiment was to ascertain the possibility of abiogenetic synthesis of nucleosides (one of the basic components of living matter) in open space. Ampoules of RNA and DNA components in dry powder form were attached to the outer skin of the orbital station and exposed in varying degrees to the conditions of space. After 10 months, the ampoules were removed by cosmonauts during EVA and subsequently returned to Earth. Laboratory studies later indicated that nucleoside analogs—in some cases different from those manufactured by living cells—were formed in the ampoules by a condensation reaction. Ampoules exposed to all conditions of space demonstrated reactions twice as rapid as other ampoules that were shielded from UV radiation. This is the first demonstration of nucleic acid formation in space.

## REFERENCES

- Aleksandrov, I.A., Sellvra, A.I., Timoshenko, T.Ye., Ryabukha, N.A., Leosko, V.A., & Bobkov, A.G. Morphological and functional evaluation of the external respiratory system of rabbits with subacute oxygen toxicity. *Space Biology and Aerospace Medicine*, 1981, 15(3): 34-37.
- Alelyukhin, A.A., & Khachatur'yants, M.L. Dynamics of some physiological functions during 10-day hypodynamia with reproductive suggestion of hypergravity and hypogravity states. In V.G. Volkov (Ed.), *Methodological and technical problems of experimental psychophysiology*. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 9/81), 13 July 1981. Trans. from *Metodicheskiye i tekhnicheskiye voprosy eksperimental'noy psikhofiziologii*. Moscow: Izdatel'stvo "Nauka," 1980, pp. 90-95. (abstract)
- Amosov, N.M. (Ed.). Theoretical studies of physiological systems. Mathematical modeling. NDB 1261. Trans. from *Teoreticheskiye issledovaniya fiziologicheskikh sistem. Matematicheskoye modelirovaniye*. Kiev: Izdatel'stvo "Naukova dumka," 1977.
- Anisimov, B.V., Zagorskaya, Ye.A., Lyubarskaya, I.I., & Popova, I.A. Some biochemical parameters of healthy man in a sealed chamber with periodic ionization of air. *Space Biology and Aerospace Medicine*, 1981, 15(3):78-81.
- Arinchin, N.I. Peripheral "hearts" of man. Section: Movement and space. NDB 1068. Trans. from *Perifericheskoye "serdtsa" cheloveka*. Minsk: Izdatel'stvo "Nauka i tekhnika," 1980, pp. 64-67.
- Arlashchenko, N.I. Significance of vestibular system trophics in the mechanism of vestibulovegetative manifestations. *Space Biology and Aerospace Medicine*, 1981, 15(3):89-91.
- Arsent'yeva, I.V. Mathematical modeling of human cardiovascular system reactions during postural and exercise tests. *Space Biology and Aerospace Medicine*, 1981, 15(3):31-34.
- Azhayev, A.N. Physiological and hygienic aspects of the effects of high and low temperatures. *Space Biology and Aerospace Medicine*, 1981, 15(3):94. (book review)
- Barinberg, A., & Barinberg, V. How to measure the rate of blood flow. NDB 1215. Trans. from *Khimiya i Zhizn*, 1979, 6:38-40.
- Bayevskiy, R.M. Prognosis of borderline states between normal and pathology. *Space Biology and Aerospace Medicine*, 1981, 15(3):91-92.
- Belyanin, V.N., Sid'ko, F.Y., & Trenkenshu, A.P. Activity of a photosynthesizing culture of microalgae. Ch. 4: Culture of microalgae as the regenerating element in a biological life support system for man. NDB 1066. Trans. from *Energetika fotosinteziruyushchey kul'tury mikrovdorosley*. Novosibirsk: Izdatel'stvo "Nauka," 1980.
- Beregovoy, G.T., & Khachatur'yants, L.S.(Eds.). Cosmonaut performance in flight, and increase in efficiency thereof. NDB 1179. Trans. from *Deyatel'nost kosmonavta v polete i povsheniye yeye effektivnosti*. Moscow: Izdatel'stvo "Mashinostroyeniye," 1981.

- Breslav, I.S., & Kalacheva, Ye.L. Effect of density of gas mixtures on the operation of the respiratory apparatus. NDB 1145. Trans. from *Fiziologiya Cheloveka*, 1980, 6(2):317-322.
- Bryuzgina, M.I., Popova, T.S., Lebedev, V.I., & Gal'perin, Yu.M. Effect of soft diet on the process of formation of enteric contents during natural digestion. *Space Biology and Aerospace Medicine*, 1981, 15(3):85-87.
- Chebotaev, D., & Frol'kis, V. Regulation of "biological clocks" (biorhythms). NDB 966. Trans. from *Meditsina Segodnya Seriya "Meditsina,"* 1981, 1:11-15.
- Chestukhin, V.V., Katkov, V.Ye., Troshin, A.Z., Nesvetov, V.N., & Petrov, A.A. Left ventricular function and pulmonary circulation in healthy subjects during ortho- and antiorthostatic tests. NDB 1494. Trans. from *Kardiologiya*, 1981, 5:68-75.
- Chizhov, S.V., Sinyak, Yu.Ye., Shikina, M.I., & Luzina, T.I. Evaluation of methods for mineralizing recycled potable water using a conductometer, *Space Biology and Aerospace Medicine*, 1981, 15(3):75-78.
- Donina, Zh.A. The effect of density in a gas medium on total gas exchange and the oxygen level in muscle tissue. In *Structural-functional aspects of neurophysiology (Collection of scientific works from the Young Scientists and Specialists' Conference)*. NDB 1221. Trans. from *Strukturno-funktsional'nyye aspekty neyrofiziologii (Sbornik nauchnykh trudov Konferentsii Molodykh Uchenykh i Spetsialistov)*. Leningrad: USSR Academy of Sciences, 1978, pp. 81-84.
- Fofanov, V.I., Abakumova, I.A., Gur'yeva, T.S., Tresvyatskaya, N.A., Markaryan, M.V., Smirnova, T.A., & Panferova, N.Ye. Use of some nutrients from inedible plant sources as food. *Space Biology and Aerospace Medicine*, 1981, 15(3):50-53.
- Galitskiy, A. The soothing heat. NDB 1458. Trans. from review in *Fizkul'tura i Sport*, 1981, 4:20-22. (book review)
- Galle, R.R. Quantitative evaluation of clinical manifestations of motion sickness. *Space Biology and Aerospace Medicine*, 1981, 15(3):72-75.
- Gazenko, O.G., Genin, A.M., & Yegorov, A.D. Medical studies aboard Soviet manned spacecraft. *Aerospace Medicine and Biology*, September 1981, NASA SP-7011(223):141. Trans. from *Priroda*, April 1981:42-47. (abstract)
- Gazenko, O.G., Parfenov, G.P., & Shepelev, Ye.Ya. Prospects for terrestrial biology in space. From JPRS, *USSR Report: Space* (No. 12), 19 August 1981. Trans. from *Zemlya i Vselennaya*, 1981, 1:18-23.
- Glazkov, V.I., Gozenbuk, V.L., & Keirim-Markus, I.B. Activity of bone marrow hematopoiesis in man as a function of gamma-radiation dose (mathematical model). NDB 1213. Trans. from *Radiologiya*, 1978, 18(5):746-748.

- Goncharova, G.I., Liz'ko, N.N., Lyannaya, A.M., Shilov, U.M., Spitsa, T.I., Syrykh, G.D., & Kazantsev, V.A. Status of cosmonaut bifidoflora before and after space flights. *Space Biology and Aerospace Medicine*, 15(3):14-18.
- Grigoryan, R.D., & Palets, B.L. Models of hemodynamic reactions to factors causing redistribution of blood. In N.M. Amosov (Ed.), *Medical and physiological cybernetics*. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 8/81), 8 July 1981. Trans. from *Meditinskaya i fiziologicheskaya kibernetika*. Kiev: Institute for Cybernetics, 1980, pp. 95-98. (abstract)
- Gronskaya, N.F., & Strelin, G.S. Role of immobilization of irradiated rats in the protective effect of bone marrow shielding. NDB 918. Trans. from *Radiobiologiya*, 1980, 20(2):259-262.
- Gulyar, S.A. Effects of breathing compressed air and hyperoxia on the respiratory, circulatory, and oxygen level dynamics. NDB 1500. Trans. from *Fiziologicheskii Zhurnal SSSR*, 1980, 6:823-829.
- Gulyar, S.A., Moiseyenko, Ye.V., Sirota, S.S., Grinevich, V.A., & Skudin, V.K. Effect of maintaining humans in nitrogen-oxygen environment under a pressure of 5-12 kgf/cm<sup>2</sup> on certain indices of higher nervous activity. NDB 1156. Trans. from *Fiziologicheskii Zhurnal*, 1979, 25(5):576-584.
- Gurovskiy, N.N., & Yegorov, A.D. Some problems of space medicine. In V.I. Prishchepa (Ed.), *Twentieth anniversary of Gagarin's flight: A collection of articles*. NDB 1350. Trans. from *20 let poletu Gagarina: Sbornik statey*. Moscow: Izdatel'stvo "Znaniye," 1981, pp. 37-59.
- Il'in, Ye.A. Gravitational biology: Advances and prospects. NDB 1087. (Original source unknown)
- Il'ina-Kakuyeva, Ye.I., & Portugalov, V.V. Structural changes in the soleus muscle of rats flown aboard the Cosmos series of biosatellites and submitted to hypokinesia. *Space Biology and Aerospace Medicine*, 1981, 15(3):37-40.
- Institute of Biomedical Problems. Radiophysical research aboard the Cosmos-1129 artificial Earth satellite (joint Soviet-American K-309 experiment). NDB 1088. Trans. from *Radiatsionno-fizicheskiye issledovaniya na izd "Kosmos-1129" (sovmestnyy Sovetsko-Amerikanskiy eksperiment K-309)*, paper published by the Institute of Biomedical Problems, USSR Ministry of Health, 1980.
- Ivanov, Ye.A. Circadian cycles of efficiency level of the human operator. In V.G. Volkov (Ed.), *Methodological and technical problems of experimental psychophysiology*. NDB 967. Trans. from *Metodicheskiye i tekhnicheskiye voprosy eksperimental'noy psikhofiziologii*. Moscow: Izdatel'stvo "Nauka," 1980, pp. 58-62.
- Kamenskiy, Yu.N. Flight-related changes in parameters of external respiration in helicopter crews. *Space Biology and Aerospace Medicine*, 1981, 15(3):83-84.



- Kandror, I.S., & Rotenberg, V.S. Sleep and mental fitness. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 12/81), 18 September 1981. Trans. from *Fiziologiya Cheloveka*, 1980, 6(6):1094-1101.
- Karpov, A.N., & Zinov'yeva, L.A. Emotional reactions of operators and slow waves of cardiac rhythm. *Space Biology and Aerospace Medicine*, 1981, 15(3):26-28.
- Karpov, Ye.A. On the history of training the first cosmonauts. In V.I. Prishchepa (Ed.), *Twentieth anniversary of Gagarin's flight: A collection of articles*. NDB 1349. Trans. from *20 let poletu Gagarina: Sbornik statey*. Moscow: Izdatel'stvo "Znaniye," 1981, pp. 22-36.
- Katkov, A.I., & Kovalenko, E.A. Hypoventilatory training as a means of increasing reserve time in pure-nitrogen breathing. *Aerospace Medicine and Biology*, August 1981, NASA SP-7011(222): 123. Trans. from *Fiziologiya Cheloveka*, 1981, 7:283-288. (abstract)
- Kaznacheyev, V.P. (Ed.) Mechanisms of man's adaptation to high latitudes. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 9/81), 13 July 1981. Trans. from *Mekhanizmy adaptatsii cheloveka v usloviyakh vysokikh shirot*. Leningrad: Izdatel'stvo "Meditsina," 1980.
- Kekhayov, A.N. Space, time, motion (vestibular, visual, and auditory perceptions). NDB 1492. Trans. from review in *Zhurnal Nevropatologii i Psikiatrii imeni S.S. Korsakova*, 1981, 5:779-781. (book review)
- Khaydarliv, S.Kh. Neurocytochemical characteristics of protein and RNA metabolism during exposure to stress, including hypokinesia. In *Human and animal biochemistry. Issue 4, Protein biochemistry in the nervous system*. NDB 926. Trans. from *Biokhimiya zhivotnykh i cheloveka. Vyp. 4, Biokhimiya belkov nervoy sistemy*. Kiev: Izdatel'stvo "Naukova Dumka," 1980, pp. 70-75.
- Kitayev-Smyk, L. The world of free fall: Psychological effects of weightlessness. NDB 1270. Trans. from *Znaniye-sila*, 1981, 2:20-23.
- Knunyants, I.L. *Journal of the All-Union Chemical Society imeni D.I. Mendeleev*, 1980, 25(4): 362-480.
- Kogan, I.G., & Grozdova, T.Ya. Effect of dynamic factors in space flight on the mutagenic effect of radiation. Report II: Occurrence of recessive lethals and X-chromosome loss in oocytes of *Drosophila melanogaster*. NDB 1372. Trans. from *Genetika*, 1981, 3:455-459.
- Konstantinova, I.V., & Antropova, Ye.N. Immunological reactivity of the body during stays in confined quarters. In Yu.G. Nefedov (Ed.), *Problems of space biology. Vol. 42: Sanitary-hygienic and physiological aspects of manned spacecraft*. NDB 1087 (NASA TM-76495). Trans. from *Problemy kosmicheskoy biologii. Tom 42: Sanitarno-gigiyenicheskiye i fiziologicheskiye aspekty obitayemykh kosmicheskikh korabley*. Moscow: Izdatel'stvo "Nauka," 1980.

- Krotov, V.P., Kovalenko, E.A., Timann, G., Kasatkin, Iu.N., Mikerova, T.M., & Smirnov, V.F. Types of cardiorespiratory responses produced during acute hypoxia. *Aerospace Medicine and Biology*, August 1981, NASA SP-7011(222):123. Trans. from *Fiziologiya Cheloveka*, 1981, 7:269-276. (abstract)
- Krut'ko, V.N. Application of mathematical modeling to analysis of immunological phenomena. *Space Biology and Aerospace Medicine*, 1981, 15(3):4-14.
- Kudryashov, B.A., Shapiro, F.B., Lomovskaya, E.G., & Lyapina, L.A. The role of ACTH and glucocorticoids in nonenzymatic fibrinolysis during immobilization stress in animals. *Aerospace Medicine and Biology*, July 1981, NASA SP-7011(221):112. Trans. from *Fiziologicheskiye Zhurnal SSSR*, 1977, 63(5):735-741. (abstract)
- Kuzicheva, V. Results of nucleoside-synthesis experiments on "Salyut-6." *Sotsialisticheskaya Industriya*, 20 August 1981, No. 192 (3683):4.
- Kvetnyanski, R., & Tigranyan, R.A. Catecholamines and enzymes of their metabolism in the rat myocardium following a long-term space flight. *Space Biology and Aerospace Medicine*, 1981, 15(3):45-47.
- Lapayev, E.V., Pavlov, G.I., Voloshin, V.G., & Grishanov, V.Ye. Method of simulating hemodynamic effects of weightlessness and refinement of the Chibis protective vacuum suit used in this method. From *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 12/81), 18 September 1981. Trans. from *Izvestiya Akademii Nauk SSSR: Seriya Biologicheskaya*, 1981, 3:443-445.
- Lebedeva, N.N., & Pikovskiy, Yu.B. Methods for studying group operator performance. In V.G. Volkov (Ed.), *Methodological and technical problems of experimental psychophysiology*. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 9/81), 13 July 1981. Trans. from *Metodicheskiye i tekhnicheskkiye voprosy eksperimental'noy psikhofiziologii*. Moscow: Izdatel'stvo "Nauka," 1980, pp. 90-95. (abstract)
- Lekar', P.G. Clinical neurophysiology and the pathology of hypokinesia. NDB 1280. Trans. from review in *Zhurnal Nevropatologii i Psikhatriy imeni S.S. Korsakova*, 1981, 4:621-623. (book review)
- Lissova, O.I. Effect of change in total blood volume and orthostatic tests on hemodynamics. In N.M. Amosov (Ed.), *Medical and physiological cybernetics*. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 8/81), 8 July 1981. Trans. from *Meditsinskaya i fiziologicheskaya kibernetika*. Kiev: Institute of Cybernetics, 1980, pp. 95-98. (abstract)
- Lobova, T.M., & Potapov, P.P. Dehydrogenase activity in the pentose phosphate oxidative pathway and relation thereof to lipid metabolism under hypokinetic conditions. *Space Biology and Aerospace Medicine*, 1981, 15(3):47-50.

- Lomov, B.F. Psychology: Results, problems, and experiments. NDB 1443. Trans. from *Priroda*, 1981, 2:24-31.
- Mel'nik, B.Ye., Krivaya, A.P., & Paladiy, Ye.S. Effect of hypokinesia on catecholamine balances and bioelectrical activity of some structures of the brain. In M.N. Lozan (Ed.), *Fauna, ecology and physiology of animals (Problems of biology and environmental protection. Inter-VUZ collection)*. NDB 1175. Trans. from *Fauna, ekologiya i fiziologiya zhivotnykh (Voprosy biologii i okhrany prirody. Mezvuzovskiy sbornik)*. Kishinev: Izdatel'stvo "Shtiintsa," 1980, pp. 84. (abstract)
- Mikhalkina, N.I., & Sverchkova, V.S. Activity of lactate dehydrogenase in the heart of rats during hypoxia and hypercapnia. NDB 1138. Trans. from *Voprosy Meditsinskoy Khimii*, 1981, 27(2): 172-175.
- Miroshnichenko, L.I. Biological effects of cosmic rays. In N.P. Dubinin (Ed.), *Mutagenesis Induced by physical factors*. NDB 1042. Trans. from *Mutagenez pri deystvii fizicheskikh faktorov*. Moscow: Izdatel'stvo "Nauka," 1980, pp. 187-205.
- Molseyeva, N.I., & Sysuyev, V.M. The time environment and biological rhythms. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 10/81), 25 August 1981. Trans. from *Vremennaya sreda i biologicheskiye ritmy*. Leningrad: Izdatel'stvo "Nauka," 1981.
- Moskalenko, Yu.E. Functional steadiness of the cerebral circulatory system under altered gravitational conditions. *Aviation, Space, and Environmental Medicine*, 1981, 52(3):159-162.
- Nefedov, Yu.G. (Ed.). *Problems of space biology. Vol. 42: Sanitary-hygienic and physiological aspects of manned spacecraft*. NDB 1077 (NASA TM-76495). Trans. from *Problemy kosmicheskoy biologii. Tom 42: Sanitarno-gigiyenicheskiye i fiziologicheskiye aspekty obitayemykh kosmicheskikh korabley*. Moscow: Izdatel'stvo "Nauka," 1980.
- Novikov, M.A. Psychophysiological and ecopsychological aspects of interpersonal interactions in autonomous situations. In B.F. Lomov (Ed.), *Communication problems in psychology*. NDB 1488. Trans. from *Problemy obscheniya v psikhologii*. Moscow: Nauka, 1980, pp. 178-217.
- Novikov, V.E., & Ilyin, E.A. Age-related reactions of rat bones to their unloading. *Aviation, Space, and Environmental Medicine*, 1981, 52(9):551-553.
- Novikov, V.S., & Arzumanov, A.A. Increasing bodily, non-specific resistance of sailors at sea. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (No. 9), 16 September 1981. Trans. from *Voyenno-Meditsinskiy Zhurnal*, 1981, 3:44-45.
- Pak, Z.P., Koloskova, Yu.S., Bezumova, Yu.Ye., Petina, V.P., & Spirayeva, M.M. Toxicological and hygienic studies of water recycled from oxidant-containing fluids. *Space Biology and Aerospace Medicine*, 1981, 15(3):56-59.

- Pal'chun, V.T., Vishnyakov, V.V., & Bulayev, Yu.O. Study of the function of the vestibular analyzer with sine rotation among healthy persons. NDB 902. Trans. from *Vestnik Otorinolaringologii*, 1981, 1:8-11.
- Pikovskiy, Yu.B., & Khachatur'yants, L.S. Functional shortage of time in operator work. In V.G. Volkov (Ed.), *Methodological and technical problems of experimental psychophysiology*. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 9/81), 13 July 1981. Trans. from *Metodicheskiye i tekhnicheskiye voprosy eksperimental'noy psikhofiziologii*. Moscow: Izdatel'stvo "Nauka," 1980, pp. 90-95. (abstract)
- Pisarenko, G.S. (Ed.). *Space research in the Ukraine*. NDB 1190. Trans. from *Kosmicheskiye issledovaniya na Ukraine*. Kiev: Izdatel'stvo "Naukova Dumka," 1978.
- Pleshan', A., & Kozlovskiy, E. Results were improved. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (No. 8), 14 September 1981. Trans. from *Aviatsiya i Kosmonavtika*, 1981, 5:17.
- Popov, I.P. Determination of oxygen consumption by laboratory animals under reduced barometric pressure. NDB 1142. Trans. from *Fiziologicheskiye Zhurnal*, 1980, 26(5):701-703.
- Reushkina, G.D., Reushkin, V.N., & Roslyakov, N.P. The effect of hypokinesia on the electrolyte content in the organs of animals. NDB 1301. Trans. from *Patologicheskaya Fiziologiya in Eksperimental'naya Terapiya*, 1981, 2:92. (abstract)
- Rudenko, F.V. Effect of persistent regional vascular hypotension on growth of malignant tumors. *Space Biology and Aerospace Medicine*, 1981, 15(3):65-67.
- Sarsikov, I.Yu. Optimum vestibular "coordination" of man with a moving device. Abstract filed with the All-Union Scientific Research Institute of Medical and Medico-technical Information. *Space Biology and Aerospace Medicine*, 1981, 15(3):96. (abstract)
- Savchenko, N.Ya., Portman, A.I., & Ryzhov, N.I. Effect on mouse skin of radiation differing in linear energy transfer. *Space Biology and Aerospace Medicine*, 1981, 15(3):63-65.
- Savina, V.P., & Kuznetsova, T.I. Sources of pollution of cabin atmosphere by trace impurities, and toxicological evaluation thereof. In Yu.G. Nefedov (Ed.), *Problems of space biology. Vol. 42: Sanitary-hygienic and physiological aspects of manned spacecraft*. NDB 1077 (NASA TM-76495). Trans. from *Problemy kosmicheskoy biologii. Tom 42: Sanitarno-gigiyenicheskiye i fiziologicheskiye aspekty obitayemykh kosmicheskikh korabley*. Moscow: Izdatel'stvo "Nauka," 1980.
- Sergeev, A.A. Soviet literature in aviation, space and high-altitude biology and medicine (No. 3). *Aerospace Medicine and Biology*, August 1981, NASA SP-7011(222):131. Trans. from *Otechestvennaya literatura po aviatsionnoi kosmicheskoi i vysokogornoj biologii i meditsine* (No. 3). Leningrad: Izdatel'stvo "Nauka," 1980. (abstract)

- Shilov, V.M., & Liz'ko, N.N. Microecology of the intestine under extreme conditions. In Yu.G. Nefedov (Ed.), *Problems of space biology*. Vol. 42: *Sanitary-hygienic and physiological aspects of manned spacecraft*. NDB 1077 (NASA TM-76495). Trans. from *Problemy kosmicheskoy biologii*. Tom 42: *Sanitarno-gigiyenicheskiye i fiziologicheskiye aspekty obitayemykh kosmicheskikh korabley*. Moscow: Izdatel'stvo "Nauka," 1980.
- Sidel'nikov, I.A. An objective method for evaluating vestibular stability from determination of vector changes in the indices for nystagmus following cumulative Coriolis accelerations. NDB 1368. Trans. from *Izvestiya Akademii Nauk SSSR: Seriya Biologicheskaya*, 1981, 2:276-293.
- Sinyak, Yu.Ye., & Shul'gina, I.L. Recovery of synthetic organic acids from human waste in closed life support systems. *Space Biology and Aerospace Medicine*, 1981, 15(3):60-62.
- Stupakov, G.P., Volozhin, A.I., & Didenko, I.Ye. Strength and mineral composition of human vertebrae after prolonged bed confinement. NDB 1509. Trans. from *Byulleten' Eksperimental'noy Biologii i Meditsiny*, 1981, 5:544-546.
- Sulimo-Samuylo, Z.K., Bagrova, N.D., & Yendal'tsev, B.V. Effect of physical training on the resistance of the human body to high temperature. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (No. 8), 14 September 1981. Trans. from *Voyenno-Meditsinskiy Zhurnal*, 1981, 4:51-53.
- Suvorov, P.M., Artamonov, N.N., Tarnovskiy, B.N., & Bykova, Yu.I. Endurance of lower body negative pressure by pilots with neurocirculatory dystonia of the hypertensive type. *Space Biology and Aerospace Medicine*, 1981, 15(3):70-72.
- Tavadyan, D.S., & Goncharov, N.P. Circadian rhythms of hormonal activity of the suprarenals of rhesus macaques during hypokinesia. NDB 915. Trans. from *Problemy Endokrinologii*, 1981a, 27(1):76-81.
- Tavadyan, D.S., & Goncharov, N.P. The function of the hypothalamic-hypophyseal-gonadal system in *Macaca mulatta* in prolonged hypokinesia. NDB 1273. Trans. from *Zhurnal Evolyutsionnoy Biokhimii i Fiziologii*, 1981b, 17(2):216-217.
- Tixador, R., Tichoille, G., Raffin, J., Bost, R., Kojarinov, V., & Lepskye, A. The CYTOS biological experiments carried out on the Soviet orbital station Salyut 6. *Aviation, Space, and Environmental Medicine*, 1981, 52(8):485-487.
- Tkachenko, V.V. Rhythms and biorhythms of work. From JPRS, *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (No. 9), 16 September 1981. Trans. from *Mashinostroitel'*, 1981, 5:13-14.
- Torbenko, V.P., & Kasavina, B.S. Functional biochemistry of bone tissue. *Space Biology and Aerospace Medicine*, 1981, 15(3):93. (book review)

Tsvetov, Ye.P., Razin, S.I., & Rychko, A.V. Functional-morphological parallels of the hypothalamo-pituitary-adrenal system response reaction to long-term hypokinesia. *Aerospace Medicine and Biology*, July 1981, NASA SP-7011(221):112. Trans. from *Vrach. Delos*, 1975, 9:9-14. (abstract)

Tyurin, V. In space—by Moscow time. NDB 912. Trans. from *Sputnik*, 1980, 1:138-142.

Uzhdevini, E.R. Group relations among animals: Some aspects of population physiology in pharmacology and toxicology. From *USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 10/81), 25 August 1981. Trans. from *Gruppovyye otnosheniya zhivotnykh: Nekotoryye aspekty populyatsionnoy fiziologii v farmakologii i toksikologii*. Leningrad: Izdatel'stvo "Nauka," 1980.

Vaulina, E.N. Investigation of mutagenic factors of space flight. In N.P. Dubinin (Ed.), *Mutagenesis Induced by physical factors*. NDB 1041. Trans. from *Mutagenez pri deystvii fizicheskikh faktorov*. Moscow: Izdatel'stvo "Nauka," 1980, pp. 206-223.

Vlasov, V.D., Karnaukhov, Yu.D., & Dmitriyev, O.P. Changes in bioelectrical activity of the myocardium of flight personnel under the influence of their workload. *Space Biology and Aerospace Medicine*, 1981, 15(3):84-85.

Volovich, V.G. Man under extreme environmental conditions. From *JPRS, USSR Report: Life Sciences—Biomedical and Behavioral Sciences* (FOUO 9/18), 13 July 1981. Trans. from *Chelovek v ekstremal'nykh usloviyakh prirodnoy sredy*. Moscow: Izdatel'stvo "Mysl," 1980.

Yakovleva, N.D., Pogudina, N.A., & Brodskiy, R.A. Ultrastructure of the rat's small intestinal mucosa after flight aboard the Cosmos-936 biosatellite. *Space Biology and Aerospace Medicine*, 1981, 15(3):40-45.

Yegorov, A.D., Itsekhovskiy, O.G., Polyakova, A.P., Turchaninova, V.F., Alferova, I.V., Savel'yeva, V.G., Domracheva, M.V., Batenchuk-Tusko, T.V., Doroshev, V.G., & Kobzev, Ye.A. Results of studies of hemodynamics and phase structure of the cardiac cycle during functional test with graded exercise during 140-day flight aboard the Salyut-6 station. *Space Biology and Aerospace Medicine*, 1981, 15(3):18-22.

Yermakova, I.I., & Ivanov, K.P. Regulation and efficiency of perspiration in man on a mathematical model. NDB 1228. Trans. from *Fiziologicheskiy Zhurnal SSSR imeni I.M. Sechenova*, 1978, 64(10):1419-1425.

Zaloguyev, S.N., Viktorov, A.N., & Startseva, N.D. Sanitary-microbiological and epidemiological aspects of habitability. In Yu.G. Nefedov (Ed.), *Problems of space biology. Vol. 42: Sanitary-hygienic and physiological aspects of manned spacecraft*. NDB 1077 (NASA TM-76495). Trans. from *Problemy kosmicheskoy biologii. Tom 42: Sanitarno-gigiyenicheskiye i fiziologicheskiye aspekty obitayemykh kosmicheskikh korabley*. Moscow: Izdatel'stvo "Nauka," 1980.